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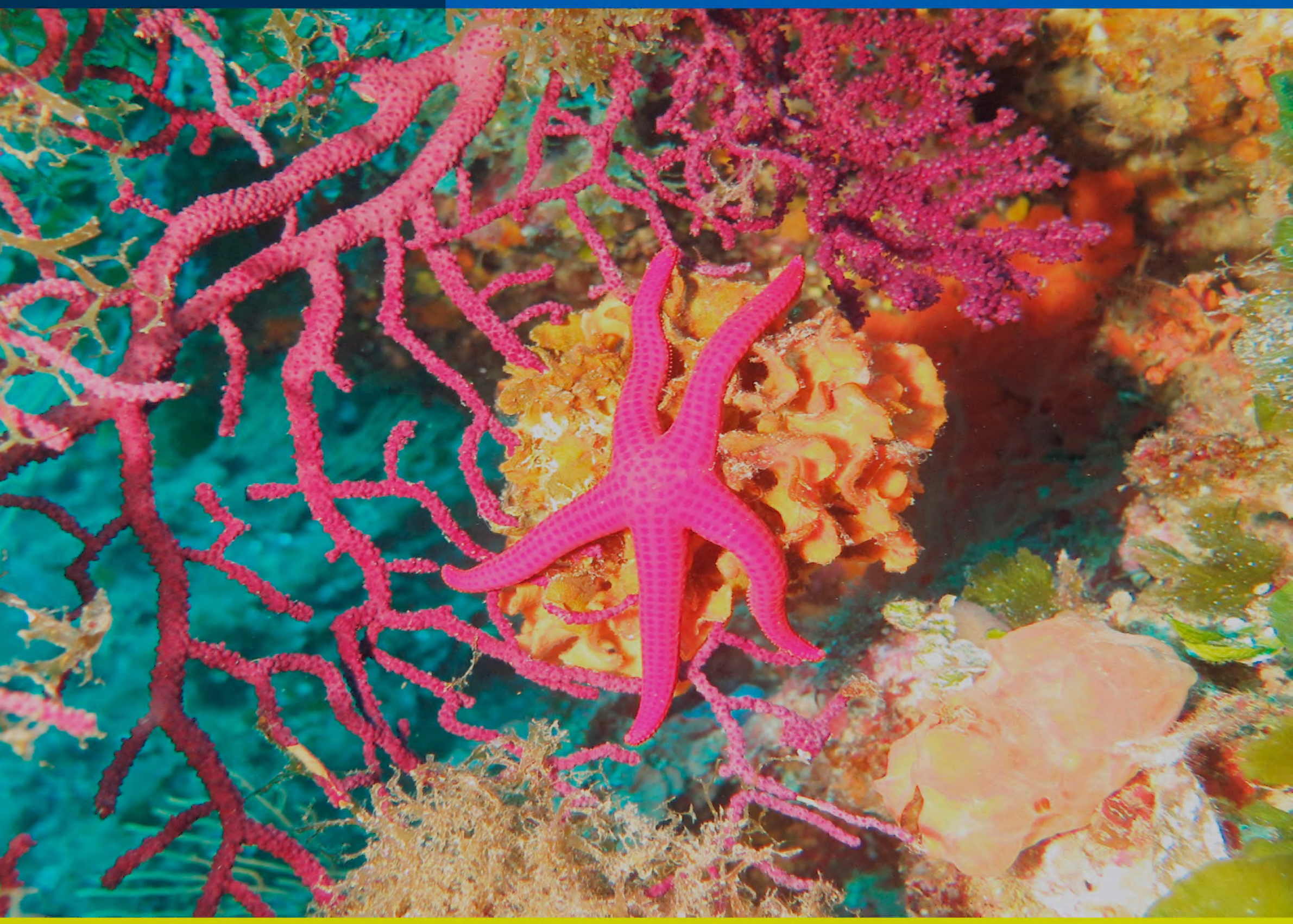

Hacelia attenuata (Gray, 1840) - Italy, Sicily (TP): San Vito Lo Capo

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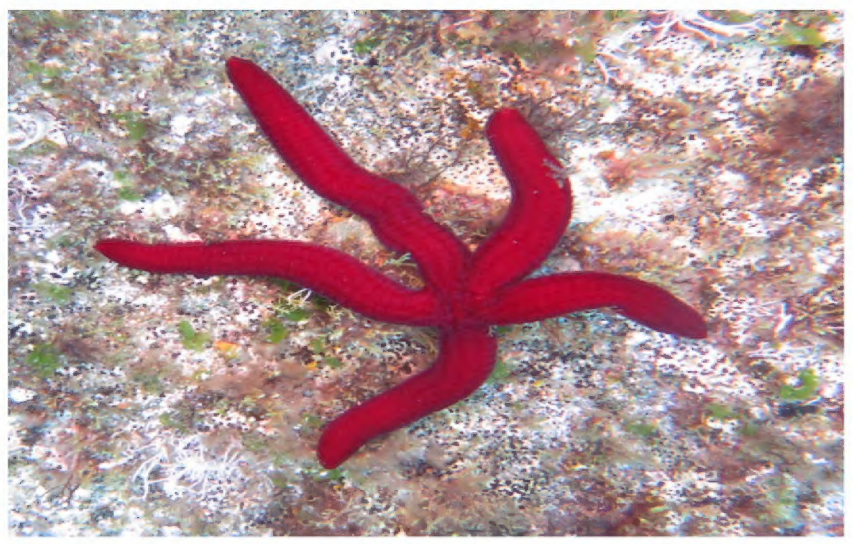
The Asteroidea De Blainville, 1830 of the Mediterranean Sea. The class Asteroidea include marine invertebrates belonging to the phylum of the Echinodermata. Echinoderms are among the oldest invertebrates and first appeared in the Cambrian Period, the first geological period of the Paleozoic Era (541-485.4 million years ago). The Asteroidea are commonly called "Starfish" or "Sea Stars" for the characteristic shape of their body. They vary in shape and size and are often brightly coloured of red or orange. They are widespread in all the seas of the world with about 2,000 species. From the ecological point of view, they are keystone species in their respective communities. The Asteroidea live in almost all types of backgrounds, from low interdital coasts to deep-sea depths, as they are usually found in less bright areas or under stones. The larval stage is bentonic. Most species are predators, eating microalgae, sponges, bivalves, and other small animals. Other species are omnivorous or detritivores, feeding on the decomposing or suspension orgaic material. At least 27 species of this group live in the Mediterranean Sea, divided into 11 families.

Stefano Reale. Istituto Zooprofilattico della Sicilia "A. Mirri", via G. Marinuzzi 3, 90129 Palermo, Italy; e-mail: stefano.reale@izssicilia.it (photos by S. Reale).



Ophidiaster ophidianus (Lamarck, 1816)

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Two new records of fossil gastropods from the Italian upper Pleistocene

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ABSTRACT The examination of numerous materials related to the upper Pleistocene ("Tirreniano" sensu Authors) from Sardinia and Calabria led to the discovery of two new fossil species for the Mediterranean basin: *Sinum bifasciatum* (Récluz, 1851) (Gastropoda Naticidae), found both in the upper Pleistocene of Sardinia and in that of Calabria, and *Morula nodulosa* (C.B. Adams, 1845) (Gastropoda Muricidae), found in the Sardinian upper Pleistocene. Both species are discussed and illustrated in this paper.

KEY WORDS *Sinum*; *Morula*; Pleistocene; Tyrrhenian.

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INTRODUCTION

The study of material coming from the upper Pleistocene of the Mediterranean basin led to the discovery of two new fossil gastropod molluscs for the Mediterranean basin: *Sinum bifasciatum* (Récluz, 1851) and *Morula nodulosa* (C.B. Adams, 1845). Both species come from deposits with the typical hot fauna with Senegalese affinity to *Persistrombus latus* Gmelin, 1791 (= *Strombus bubonius* Lamarck, 1822), *Monoplex trigonus* (Gmelin, 1791) [= *Cymathium ficoides* (Reeve, 1844)], *Gemophos viverratus* (Kiener, 1834), *Conus ermineus* Born, 1778, (= *Conus testudinarius* Hwass in Bruguière, 1792), etc. (Gignoux, 1913; Trevisan & Di Napoli, 1938; Mirigliano, 1953; Segre, 1954; Malatesta, 1954; Ruggieri & Buccheri, 1968; Settepassi, 1971; Ruggieri & Melone, 1975; Vazzana, 2008).

MATERIAL AND METHODS

The samples, collected during surface searches, come from different deposits of the upper Pleistocene from Sardinia and Calabria (see Examined material). The taxonomy follows Worms (2018) and the others cited publications.

ABBREVIATIONS. H: maximum height of the shell, measured from the apex up to the front end of the siphonic channel; L: maximum width of the shell; ex: specimen/s; CMF: Maurizio Forli collection; CPC: Paolo Crovato collection; CMB: Mauro M. Brunetti collection.

RESULTS

Systematics

Classis GASTROPODA Cuvier, 1795
Subclassis CAENOGASTROPODA Cox, 1960
Ordo LITTORINIMORPHA Golikov et Starobogatov, 1975
Superfamilia NATICOIDEA Guilding, 1834
Familia NATICIDAE Guilding, 1834
Genus *Sinum* Röding, 1798
Type species: *Sinum haliotoideum* Linnaeus, 1758

Sinum bifasciatum (Récluz, 1851) (Figs. 1–3)

Sigaretus bifasciatus Récluz, 1851: 190, tab. 6, figs. 3–4

Sigaretus philippii Weinkauff, 1883: 23, tab. 5, figs. 1– 3
Sinum bifasciatum Settepassi, 1972, tab. 2
Sinum bifasciatum Ardovini & Cossignani, 2004: 119
Sinum bifasciatum Rolán, 2005: 91, fig. 383
Sinum bifasciatum Giannuzzzi Savelli et al., 1997: 202, figs. 831a-f.

EXAMINED MATERIAL. Porto Alabe (Nuoro, Italy) "Tirreniano", 1 ex, CMB; Trumbacà (Reggio Calabria, Italy) "Tirreniano", 1 ex, CMF; Saracinello (Reggio Calabria, Italy) "Tirreniano", 4 ex, CPC.

DESCRIPTION. Shell oval, depressed, not very robust. Maximum width of the shells (L): 17.5 mm (Porto Alabe) and 11.2 mm (Trumbacà). Protoconch composed of three whorls. Teleoconch largely formed by the last lap, very wide. Sculpture composed of numerous spiral cords separated by narrow furrows. Umbilicus absent.

DISTRIBUTION. *Sinum bifasciatum* has a very wide geographical distribution, ranging from the western Mediterranean Sea (Giannuzzi-Savelli et al., 2002) to all of West Africa, up to Angola (Ardovini & Cossignani, 2004; Rolán, 2005).

REMARKS. For *S. bifasciatum* it is the first record as a fossil for the Mediterranean basin. Among the two currently known species of the genus *Sinum* present in the Pliocene of the Mediterranean basin, *S. bifasciatum* bears some resemblance to *S. striatum* (De Serres, 1829) (Fig. 3). From this species, *S. bifasciatum* differs mainly for the different spiral sculpture as specified also by Pedriali & Robba (2009): "*The Mediterranean and West African species* Sinum bifasciatum *(Récluz, 1851) has a larger, 3 whorled protoconch whith rapidly expanding last whorl, a more depressed teleoconch and narrowed spirals separated by shallow, narrow grooves". Sinum bifasciatum* shows greater differences with the other Pliocene species, *S. perregulare* (Sacco, 1891) (see figures published in Pedriali & Robba, 2009), of smaller dimensions and with the presence of an evident umbilicus.

Ordo NEOGASTROPODA Wenz, 1938
Superfamilia MURICOIDEA Rafinesque, 1815
Familia MURICIDAE Rafinesque, 1815
Genus *Morula* Schumacher, 1817
Type species: *Morula papillosa* Schumacher, 1817

Morula nodulosa (C.B. Adams, 1845) - Fig. 4

Purpura nodulosa C.B. Adams, 1845: 2

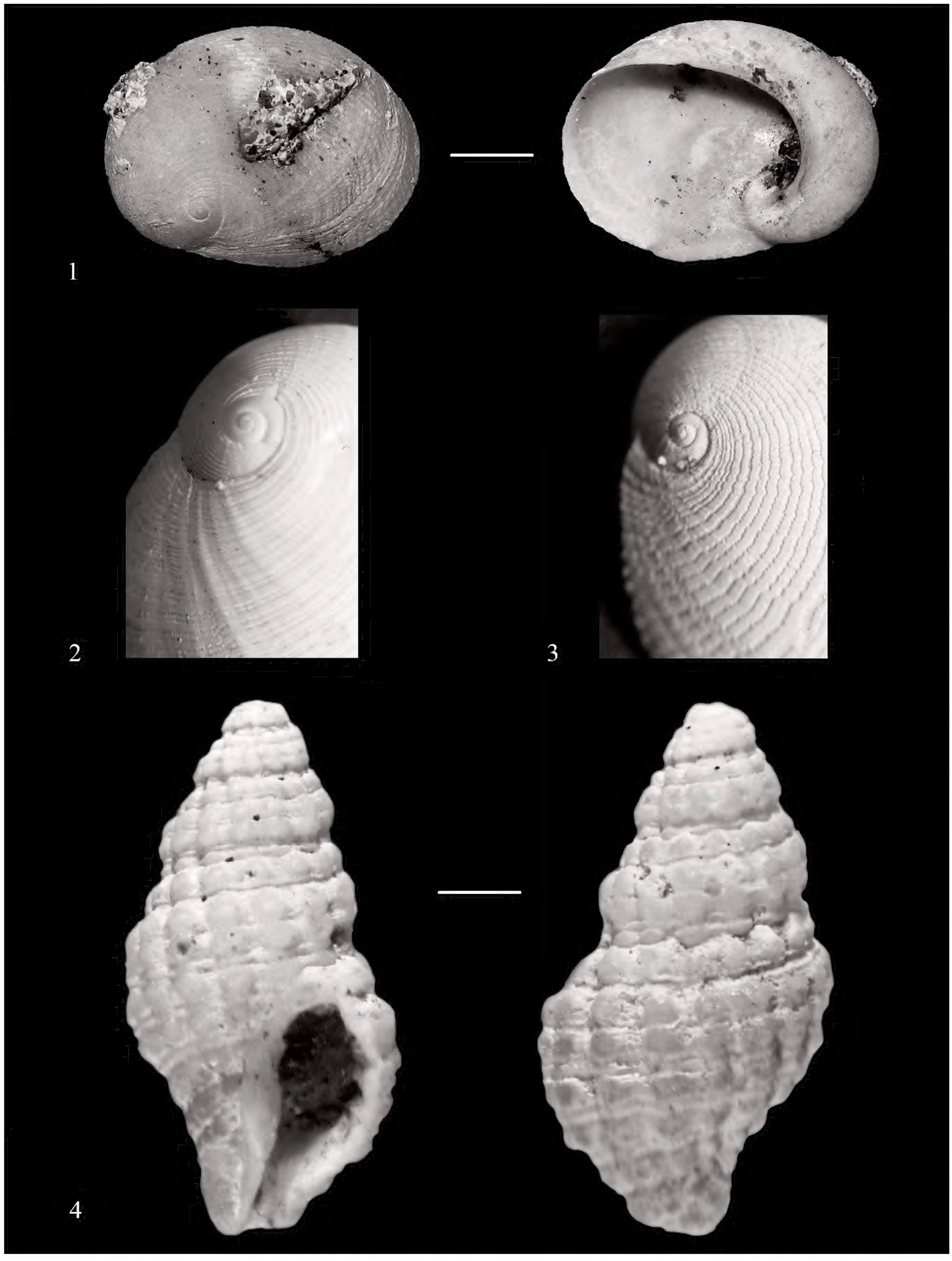
Ricinula ferruginosa Reeve, 1846: 50, tab. 1–6.
Morula nodulosa Houart, 1997: 83, figs. 174–175, 197, 256–260
Morula nodulosa Ávila et al., 2002: 354, figs. 100–103
Morula nodulosa Ardovini & Cossignani, 2004: 155–156
Morula nodulosa Rolán, 2005: 129, figs. 532–533.

EXAMINED MATERIAL. Porto Alabe (Nuoro) "Tirreniano", 2 ex, CMB.

DESCRIPTION. Shell sturdy biconoidal, with multispiral protoconch, smooth. Maximum height of the shell (H): 8 mm. Teleoconch with 5 convex whorls, sculpture robust, formed by large roundish nodules originating from the crossing of the strong axial ribs with the spiral cords. The oval opening has 4–5 robust round teeth on the outer lip, 2–3 poorly visible teeth are present on the columellar side. Short siphonal channel, slightly bent to the left. Umbilicus absent.

DISTRIBUTION. This species has a very wide, amphitlantic geographical distribution, from the Caribbean to the whole of West Africa to Angola (Houart, 1997; Rolán, 2005). Reported as a fossil of the Upper Pleistocene of the Azores Islands (Garcia-Talavera, 1990; Ávila et al., 2002, 2008).

REMARKS. This is the first record of *M. nodulosa* as a fossil for the Mediterranean basin. Houart (1997) illustrated the protoconch, the radula and the typical material of this species that comes from Jamaica. The reports of *M. nodulosa* as a fossil of the upper Pleistocene are all related to the island of Santa Maria, the Azores archipelago (Garcia-Talavera, 1990; Ávila et al., 2002, 2008). Ávila et al. (2008) report *M. nodulosa* as belonging to a group of species that left the Azores during the last glaciation, ascribing it to the genus *Trachypollia* Woodring, 1928. The material from the Sardinian Pleistocene is smaller than today's populations.



Figures 1, 2. *Sinum bifasciatum* (Récluz, 1851). Fig. 1: Porto Alabe (Nuoro, Italy) "Tirreniano", L = 17.5 mm, CMB. Fig. 2: Trumbacà (Reggio Calabria) "Tirreniano", detail of the sculpture, L = 11.2 mm, CMF. Figure 3. *Sinum striatum* (De Serres, 1829) Poggio alla Staffa (Siena, Italy), Zanclean, detail of the sculpture, L = 16 mm, CMB. Figure 4. *Morula nodulosa* (C.B. Adams, 1845) Porto Alabe (Nuoro) "Tirreniano", H = 8 mm, CMB.

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Sponges (Porifera) as bioindicator species of environmental stress from de Gulf of Annaba (Algeria)

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ABSTRACT The aim of the study was to determine seasonal variations of two biomarkers of oxidative stress, Glutathione (GSH) and Glutathione S-transferases (GSTs), in sponge *Sarcotragus spinosulus* Schmidt, 1862 (Porifera Irciniidae). The samples were collected during the four seasons in 2016–2017 at two sites in the Gulf of Annaba (northeast of Algeria): Cape de Garde, which is some distance from any source of pollution, is considered a relatively clean site, while Alzon is a site exposed to various sources of industrial, urban and harbour pollution. The results show a significant seasonal decrease in GSH rate in Alzon compared with those at Cape de Garde. Moreover, GST activity increased significantly in Alzon relative to Cape de Garde site, with a maximum activity showed in autumn. This difference between those two sites was observed for all seasons, with more effect in spring and winter. The results obtained showed that under stressful conditions due to anthropogenic factors, some physiological processes of sponges can be affected. Thus, *S. spinosulus* appears to be a suitable sentinel species for the assessment of ecotoxicological risk in the Gulf of Annaba. Sponges present most of the characteristics researched in bioindicators of pollution and consequently have been proposed to constitute a "Sponge Watch Program".

KEY WORDS Sponges; Marine Pollution; Biomarkers; Mediterranean; Bioindicator.

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INTRODUCTION

Highly productive areas such as estuaries and coastal areas are among the most widely modified and threatened ecosystems, mainly due to urban development, industrialization and tourism (Clark, 2011; Walker et al., 2012). As a result, complex mixtures of contaminants are continually released into these ecosystems, reducing water quality and placing severe restrictions on organisms. This can ultimately lead to a decline in natural resources (Cajaraville et al., 2000; Monserrat et al., 2007; Cravo et al., 2009). Among these areas, the Gulf of Annaba is constantly threatened because of its proximity to port activities, urban and industrial discharges and active agricultural areas of eastern Algeria.

In recent years, a number of biomarkers have been introduced into environmental biomonitoring programs for the assessment of stress caused by pollution, particularly in aquatic organisms (Müller et al., 2000). These biomarkers include (i) exposure biomarkers, which are (only) indicative of exposure to environmental stress, and (ii) effect biomarkers, which are indicative of both exposure and occurrence of adverse effects (Sanders, 1990). The goal of biomarker-based programs is to set up early warning systems to detect environmental stresses before irreversible damage occurs.

Contaminants usually appear in the environment as complex mixtures that can cause interactive effects on biota that can not be evaluated by chemical analysis alone. For this purpose, biomarkers offer an integrated assessment of exposure levels and effects of pollutants on wildlife. Several biomarkers are more specific for certain types of xenobiotics, and therefore the use of a biomarker battery associated with chemical analyses has been strongly recommended for inclusion in monitoring programs (OSPAR Commission, 2000; ICES, 2008). Two biomarkers were selected in this study; Glutathione (GSH), tripeptide, capable of directly inactivating radical species by neutralizing them, abd Glutathione S transferase (GST), a phase II enzyme involved in the detoxification of organic xenobiotics (Habig et al., 1974; Lee et al., 1988).

It is only in the last 20 years that sponges have been used as bioindicators for environmental risk assessment, as respond in a very sensitive manner (Müller et al., 2000), and are able to filter every day a volume of water corresponding to several times their own body volume (Vogel, 1977). Given their way of life, these organisms are natural candidates for participation in the development of quality grids. Several studies have already shown the potential of some representatives of this phylum to accumulate various xenobiotics or to express biological responses to anthropogenic disturbance. Unlike that of the upper metazoa, the tissue differentiation of sponges is poorly developed. These organisms do not have organs or real tissues.

As a result, the accumulation of xenobiotics and the biological responses that their toxicity generates must be measurable in the same way throughout the body of the animal. Finally, their very simple organization and their ability to regenerate after cuttings make them particularly suitable organisms for aquarium or experiments in situ (Abed, 2011). Much work has concerned the responses of these organisms to metal accumulation in in their midst, but very few have studied the variations of biomarkers as biological tools in assessing the quality of the environment.

In this context of biomonitoring the water quality of the Gulf of Annaba, we were interested in the antioxidant system involving glutathione and the enzymes associated with its metabolism in the tissues of *Sarcotragus spinosulus* Schmidt, 1862 (Porifera Irciniidae) at two sites for their potential as biomarkers of exposure in aquatic ecotoxicology as demonstrated by many studies on other organisms.

MATERIAL AND METHODS

The study was conducted in the Gulf of Annaba, a coastal area between Cape Rosa (8°13”E - 36°57” N) to the east and Cape de Garde to the west (7°47”E - 36°58”N). This sector is considered having a economic vocation (industrial activities, fishing and tourism).

The sampling area was delimited according to the following parameters: accessibility to the site, availability of biological material (sponges) and proximity to sources of pollution (domestic and industrial). For this, we have chosen two stations, one located in periurban area, on the west side of the port of Annaba (station I: Alzon, geographical position: 36°54’57.54”N - 07°46’13.29”E) and the other far from domestic and industrial pollution (station II: Cape de Garde, geographical position: 36°58’3.25”N - 07°47’28.3”E) (Fig. 1).

Samples of *S. spinosulus*, approximately 3 cm thick tissue and 10 individuals per station, were collected in free diving between 0 and 3 m during four seasons (2016/2017): autumn (October), winter (January), spring (April) and summer (August). The samples were transported in seawater immediately to the laboratory. All the manipulations concerning the assay of the different biomarkers studied during the grinding of the tissues of the sponge were carried out at 4 °C, in ice.

Figure 1. The study area: Gulf of Annaba (Algeria).

After milling one gram of sponge tissue, using an ultrasonic grinder, and homogenizing the tissues in the phosphate buffer (pH = 7.4, 0.1 M), the cell suspension was centrifuged At 14,000 rpm at 4 °C for 30 min, the obtained supernatant was aliquoted into eppendorf tubes and stored immediately at -24 °C for further analysis of the oxidative stress parameters.

The estimation of reduced glutathione (GSH) concentrations was carried out according to the method of Weckbecker & Cory (1988), the results obtained were expressed in µmol/mg of protein. The protein content was determined according to the colorimetric method of Bradford (1976). The activity of glutathione-S-transferase (GST) was measured according to the method of Habig et al. (1974). The values obtained were expressed in µmol/min/mg of proteins.

The results were expressed as mean ± standard error (SD). The comparison of the average values between the stations and between seasons was carried out by Student's t-test. Seasonal effects and sampling sites were tested by a two-way analysis of variance (ANOVA). All statistical analyses were performed using the Minitab 16 software (version 16.1.1).

RESULTS

The concentration of glutathione in *S. spinosulus* tissues ranged from 0.168 to 0.683 µmol GSH/mg protein for Cape de Garde sponges with a peak recorded in winter and between 0.229 and 0.483 µmol GSH/mg protein for Alzon with a peak in summer (Fig. 2). The statistical comparison between seasons shows that at the Cap de Garde the concentrations of GSH do not differ between spring and summer, while in Alzon it is similar in winter and summer. Significant differences were observed between the two stations and for the same season throughout the year (Table 1).

Figure 3 expresses GST activities, recorded in *Sarcotragus spinosulus* tissues where it was found that the maximum values recorded for the two stations are in autumn (0.283 µmol GST/min/mg protein for Cape de Garde and 0.325 µmol GST/min/mg protein for Alzon), while the minimum is observed in winter (0.124 µmol GST/min/mg protein for Cape de Garde and 0.162 µmol GST/min/mg protein for Alzon). ANOVA shows that there are no significant differences in GST activities between spring and

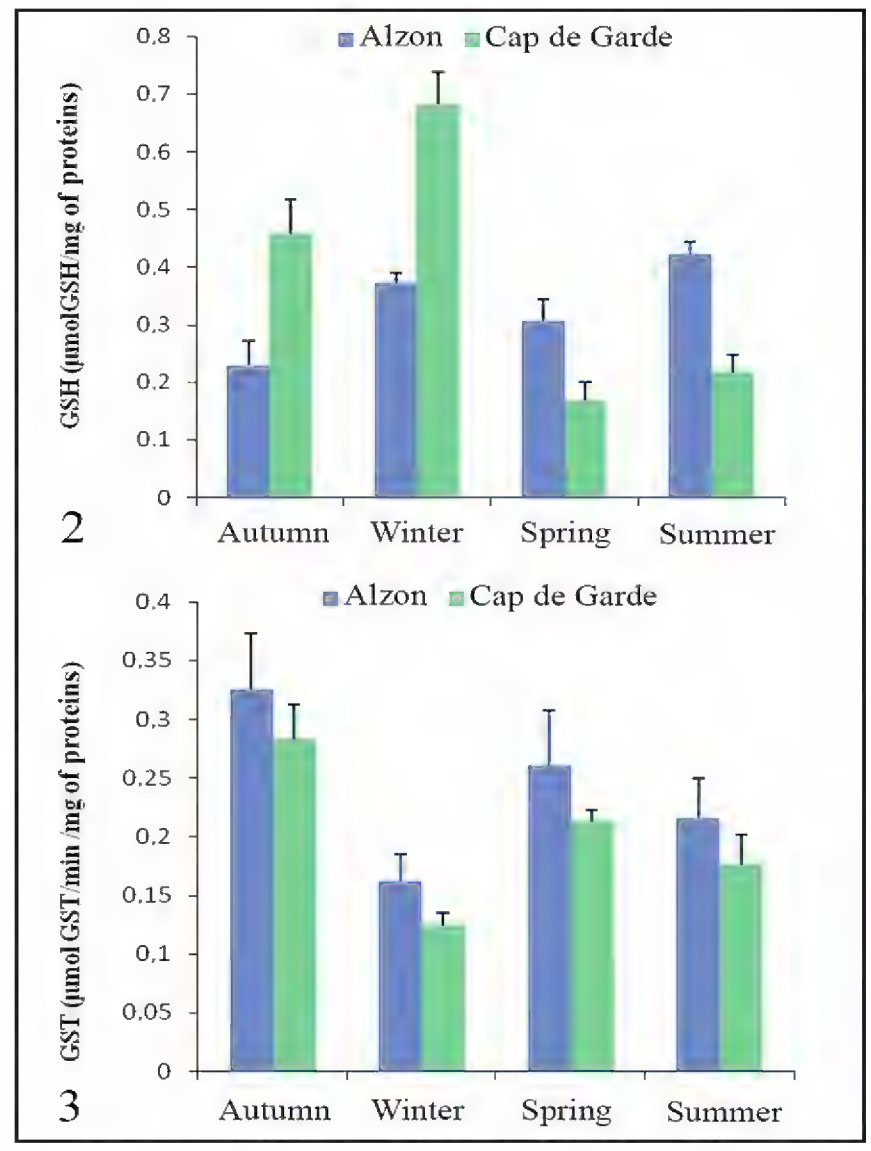

Figure 2. Variation of GSH levels in the tissues of *Sarcotragus spinosulus* of the Gulf of Annaba (Algeria).
Figure 3. Variation of GST activities in *Sarcotragus spinosulus* tissues in the Gulf of Annaba (Algeria).

Source of variation	Fobs	P	Signification
Stations	21.16	0.000	***
Seasons	56.20	0.000	***
Stations - seasons	0.05	0.984	n.s

*** highly significant difference at P < 0.001; n.s : not significant
1

Source of variation	Fobs	P	Signification
Stations	18.21	0.000	***
Seasons	112.88	0.000	***
Stations - seasons	126.36	0.000	***

*** highly significant difference at P < 0.001
2

Table 1. Analysis of variance with two classification criteria (ANOVA) of GSH activities analyzed in *Sarcotragus spinosulus* from Gulf of Annaba, Algeria (stations-seasons).
Table 2. Analysis of variance with two classification criteria (ANOVA) of GST activities in *Sarcotragus spinosulus* from Gulf of Annaba, Algeria (stations-seasons).

summer for the two sites studied. The student's 't' test shows a very significant difference for the same season (fall and spring) and between the two sampling stations (Table 2).

Seasonal variation of GST activity (μM/min/mg protein) in the tissue of *Sarcotragus spinosulus* was sampled in two sites of the Gulf of Annaba, Alzon and Cape de Garde (mean ± SD, n = 10).

DISCUSSION

A biomarker is a biological parameter and early tool for the effect of a contaminant on an organism (Mistretta & Charlier, 2013). In some cases, pollutant-induced alterations to these biological parameters can lead to behavioral and biochemical changes (Kaiser, 2001). In all the results, the effect of the seasons and the site of sampling is significantly highlighted with respect to the biomarkers of the oxidative stress of phase 1 and 2 of the detoxification system, determined at the tissue level of the sponge *S. spinosulus*. Many studies describe seasonal-related activity modifications for other antioxidant enzymes in marine bivalves *Mytilus galloprovincialis* Lamark, 1819 (Amiard et al., 2008) and freshwater bivalve *Corbicula fluminea* O.F. Müller, 1774 (Vidal, 2001). On the other hand, Livingstone (2010) observed that *M. edulis* Linnaeus, 1758 phase I detoxification enzymes are induced by seasonal parameters independent of the presence of contaminants in their living environment.

A highly significant ($P < 0.001$) reduction in glutathione rate was observed in winter and autumn at the Alzon site compared to the Cape de Garde. Indeed, it is subject not only to urban discharges without prior treatment, but also to landfills influenced by natural factors such as currents and wadis (Khammar, 2008). During these cold seasons, floods and showers cause an increase in the flow and consequently that of the turbulence of the medium following a resuspension of the fine materials, which can be at the origin of a metallic contamination. Most of these pollutants tend to accumulate in the food chain and especially at the level of sedentary organisms such as sponges. These sessile animals are very powerful active filterers, whose aquifer system gives them the ability to filter a volume of water equal to their own volume. Several studies have already shown the potential of some representatives of this phylum to accumulate various xenobiotics or to express biological responses to anthropogenic disturbance (Nakhlé, 2003). The work of Belabed (2010), Belabed & Soltani (2013) and Boutabia (2016), reported metal pollution in the Gulf of Annaba, both in water and in sediment. These results confirm the work done by Amira et al. (2011) who reported a decrease in GSH levels in *Donax trunculus* Linnaeus, 1758 collected at Sidi Salem, a site not far from Alzon. Several studies confirm the results obtained and help to better explain the relationship between the decrease in GSH levels and the level of environmental contamination (Verlecar et al., 2008).

In contrast to variations in GSH levels, GST activities show significant increases during all seasons at the anthropised site (Alzon), with a maximum noted in autumn. GST plays an important role in the detoxification of organisms (Cossu et al., 1997), it can be induced by certain pollutants (Roméo et al., 2003; Regoli et al., 2004). There are systems developed by living beings to metabolize xenobiotics that play a key role in the adaptation of living organisms to their chemical environment (Mansuy, 2013).

Our results seem consistent with the work of Deviller et al. (2005), who show in a biomonitoring study differences in GST activity with the season, with maximal activities in March–April, and the weakest in July–August. Alterations in the rate and/or activity of biotransformation enzymes are the most sensitive biomarkers of effect (Van der Oost et al., 2003). These enzymes can be inhibited or activated by exposure to a xenobiotic that is highly reliable in molluscs (Cajaraville et al., 2000). In comparison with the reference site, the seasonal increase in GST, obtained during our study, results in a strong activity of detoxification of sponges that would be related to their level of exposure to pollution, as well as probably tidal dynamics that could have a major influence on the quality and management of the pollutant load that transits through estuaries before being discharged into the sea. Similar results were obtained at Sidi Salem, with *Donax trunculus* (Abbes, 2003), where a seasonal increase in GST was also reported depending on the season. Or, the work of Funes et al. (2006), which shows an increase in GST activity following a metal pollution gradient depending on the season. Other factors may also be behind the induction of GST activities, such as temperature, pH, oxygen, as it may be related to the reproductive cycle of the animal (Chouahda,

2006). Stimulation of GST activity was also found by Canesi et al. (2007) in *Mytilus* sp. exposed to wastewater. The same results on *D. trunculus* in the Gulf of Annaba have also been reported by several other authors (Amira et al., 2011; Soltani et al., 2012). Thus, the increase in GST values would be due to oxidative stress where the activity of GST increases by catalyzing conjugation reactions between a peptide, glutathione and reactive molecules that resulted in detoxification of the body to allow their elimination (Chatterjee & Bhattacharya, 1984).

CONCLUSIONS

In this preliminary study, sponge *S. spinosulus* in particular and sponges in general appear to be excellent bioindicator models that are very sensitive to environmental variations and that could be effective in the biomonitoring programs of environmental disturbance, associated with the exploitation of biomarkers of oxidative stress that can account for a wide spectrum of pollutants, whose previous work on sponges concerned only metallothioneines (metal stress proteins).

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Jujubinus browningleeae n. sp. (Gastropoda Trochidae) from the Atlantic Ocean, a new member of the "smooth" *Jujubinus* Monterosato, 1884 complex

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ABSTRACT A new species of the gastropod family Trochidae Rafinesque, 1815, *Jujubinus browningleeae* n. sp., based on morphological characters of the shell, is here described. The new taxon is actually known only from the Gorringe Bank, located off Cape St. Vincent (Portugal, North-Eastern Atlantic). The new taxon is compared with members of the *J. curinii* species complex, which are morphologically the most similar congeners.

KEY WORDS Trochidae; *Jujubinus browningleeae* n. sp.; species complex; Atlantic Ocean.

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INTRODUCTION

The genus *Jujubinus* Monterosato, 1884, includes a small group of marine cantharidine trochid (Gastropoda Trochidae Cantharidinae) living mostly in the lower intertidal zone down to about 80–100 m depth and are constantly associated with algal turfs and marine sea-grass beds (Mariottini et al., 2013 and references therein). *Jujubinus curinii* Bogi et Campani, 2006, was the first species of this genus showing a peculiar shell sculpture, consisting of flat spiral cords without lamellae between the spiral threads (Bogi & Campani, 2006). In fact, the typical shell of *Jujubinus* displays an evident sculpture consisting of 4 to 8 spiral cords variable in size, often beaded and with tiny prosocline lamellae within interspaces between spiral threads (Monterosato, 1884). Recently, three other species with similar "smooth" shell morphology have been described by Smriglio et al. (2014, 2015), i.e., *J. eleonorae* Smriglio, Di Giulio et Mariottini, 2014, and *J. trilloi* Smriglio, Di Giulio et Mariottini, 2014, from the Sicily Channel, and *J. alboranensis* Smriglio, Mariottini et Oliverio, 2015, from the Alborán Sea. Noteworthy, all members of this complex are endemics, with a very spotted distribution: the Strait of Messina (*J. curinii*); two offshore marine shoals of the Sicily Channel, i.e., Skerki Bank (*J. eleonorae*) and Talbot Bank (*J. trilloi)*; Alboran Island, Western Mediterranean Sea (*J. alboranensis*). In the Atlantic Ocean, seamounts are isolated undersea mountains showing extraordinary submarine topographies, since they uprise steeply from the abyssal plain reaching the photic layer of shallow water seafloors, generally creating suitable habitats for benthic algae (Staudigel et al., 2010; Hall-Spencer et al., 2011).

The Gorringe Bank is a part of the Horseshoe seamounts range and Paleo Madeira (Madeiran

volcanic province), belonging to the African tectonic plate and separated from Europe by the Azores-Gibraltar fracture zone (Fernández-Palacios et al., 2011). In particular, the Gorringe seabank is over 180 km long (Anonymous, 2005) and is located southwest of Cape St. Vincent (Portugal, North-Eastern Atlantic). This latter seabank rises from 5,000 m of depth to the photic zone with peaks of <50 m below sea level and its surface is composed of recent conglomerates and lava flows with some areas of exposed carbonate rock (Anonymous, 2005). In the present paper, a new taxon from the Gorringe Bank is described, *J. browningleeae* n. sp., on the basis of morphological shell characters. The new taxon is compared with members of the *J. curinii* species complex, which are morphologically the most similar congeners. The new species is another endemic "smooth" *Jujubinus*, being currently known only from the Gorringe Bank.

MATERIAL AND METHODS

Specimens of *J. browningleeae* n. sp. were collected while SCUBA diving (30 m depth). Scanning Electron Microscopy (SEM) photographs were taken at the Interdepartmental Laboratory of Electron Microscopy (LIME, Università "Roma Tre", Rome, Italy), using a Philips XL30. Current systematics here adopted is based on World Register of Marine Species (WoRMS, http://www. marinespecies.org/; last access September 2018).

ABBREVIATIONS AND ACRONYMS. CS-PM: Carlo Smriglio-Paolo Mariottini collection, Rome, Italy; D: Diameter; FS: Frank Swinnen collection, Lommel, Belgium; H: Height; RBINS: Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium; LIME: Interdepartmental Laboratory of Electron Microscopy; SEM: Scanning Electron Microscopy.

RESULTS

Systematics

Classis GASTROPODA Cuvier, 1795
Familia TROCHIDAE Rafinesque, 1815
Genus *Jujubinus* Monterosato, 1884

TYPE SPECIES. *Trochus matonii* Payraudeau, 1826 =*Jujubinus exasperatus* (Pennant, 1777, by subsequent designation of Crosse, 1885).

Jujubinus browningleeae n. sp.
(Figs. 1–6, 7–17, 22)

DIAGNOSIS. Small and slightly turriculate shell, sculpture consisting of flat spiral cords demarcated by incised spiral lines, prosocline lamellae absent between cords.

TYPE MATERIAL. 2 shells from the type locality: Gorringe seamount Bank, 130 miles off Cape St. Vincent, Portugal North-Eastern Atlantic. Holotype: RBINS: I.G.33787/MT.3687; paratype FS.

OTHER EXAMINED MATERIAL. 200 specimens of *J. curinii* from Scilla (Strait of Messina, Mediterranean Sea) (CS-PM); 122 specimens (type material) of *J. eleonorae* from the Skerki Bank (Sicily Channel, Mediterranean Sea) (CS-PM); 90 specimens (type material) of *J. trilloi* from the Talbot Bank (Sicily Channel, Mediterranean Sea) (CS-PM); 122 specimens (type material) of *J. alboranensis* from the Alborán Island (35°56'43.99"N 3°02'03.73"W), Alborán Sea, (Western Mediterranean Sea) (CS-PM).

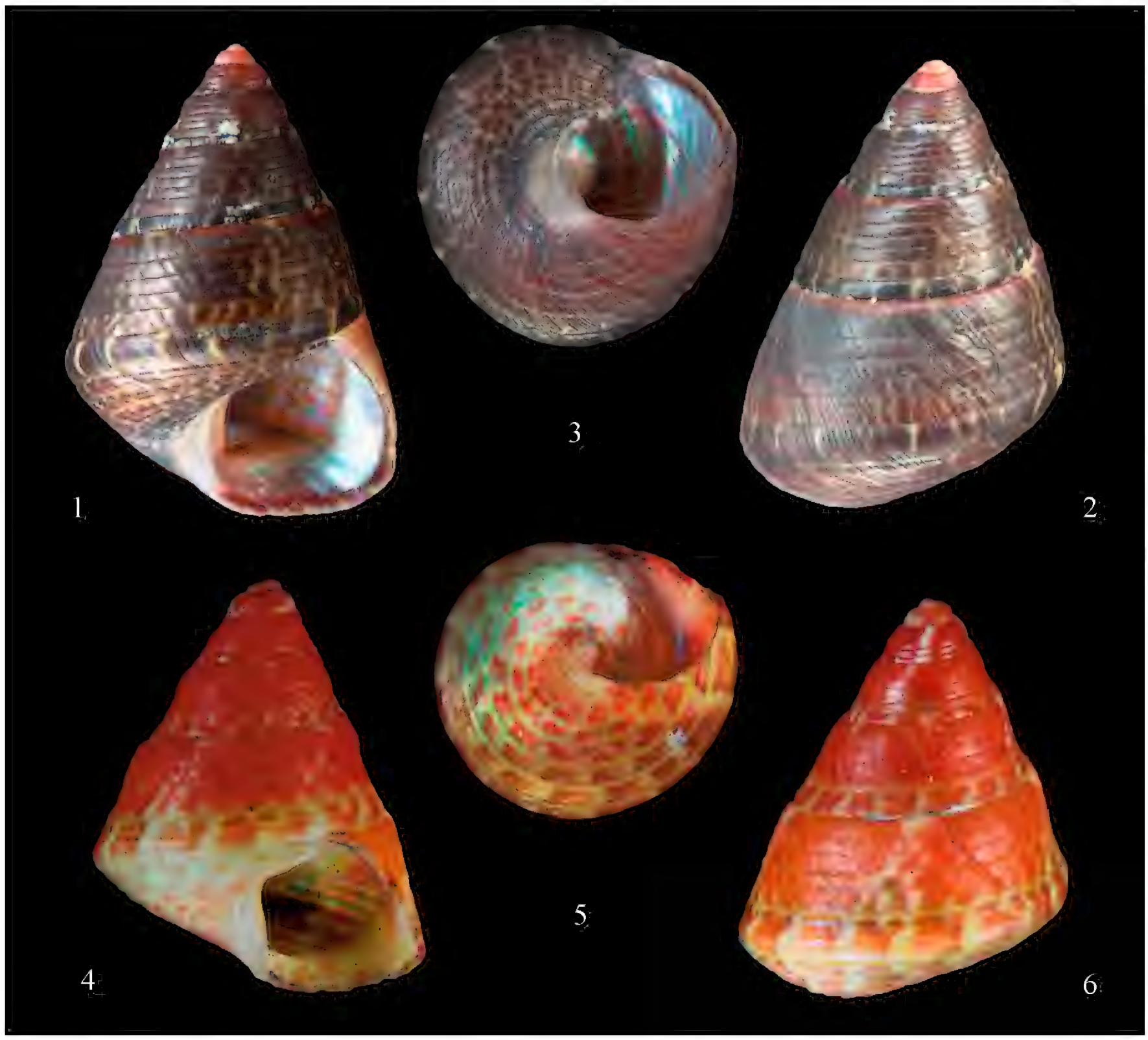
DESCRIPTION OF THE HOLOTYPE. Shell of relatively small size for the genus. Shell conical, 5.2 mm in height (H), 3.8 mm in diameter (D). Protoconch smooth, of 1.5 whorls, 410 µm width. Teleoconch of 5.5 slightly convex whorls. Sculpture consisting of 6 flat, spiral cords, regularly spaced, slightly shouldered and ratchet and demarcated by incised spiral lines. Basal cord evident, flat and slightly larger than spiral ones. Suture well incised. Teleoconch surface entirely covered by evident prosocline growth striae. Base convex, umbilicus closed and covered with a whitish callus. Aperture quadrangular, with the columellar callus thickened in the middle portion. Interior of the aperture whitish, nacreous. Colour of protoconch and small portion of the apical teleoconch whorl reddish, remaining whorls and base uniformly dark-brown with axial wavy and narrow yellow stripes.

VARIABILITY. The paratype 3.8 (H) X 3.3 (D) mm shows a protoconch of 1.5 whorls (370 µm

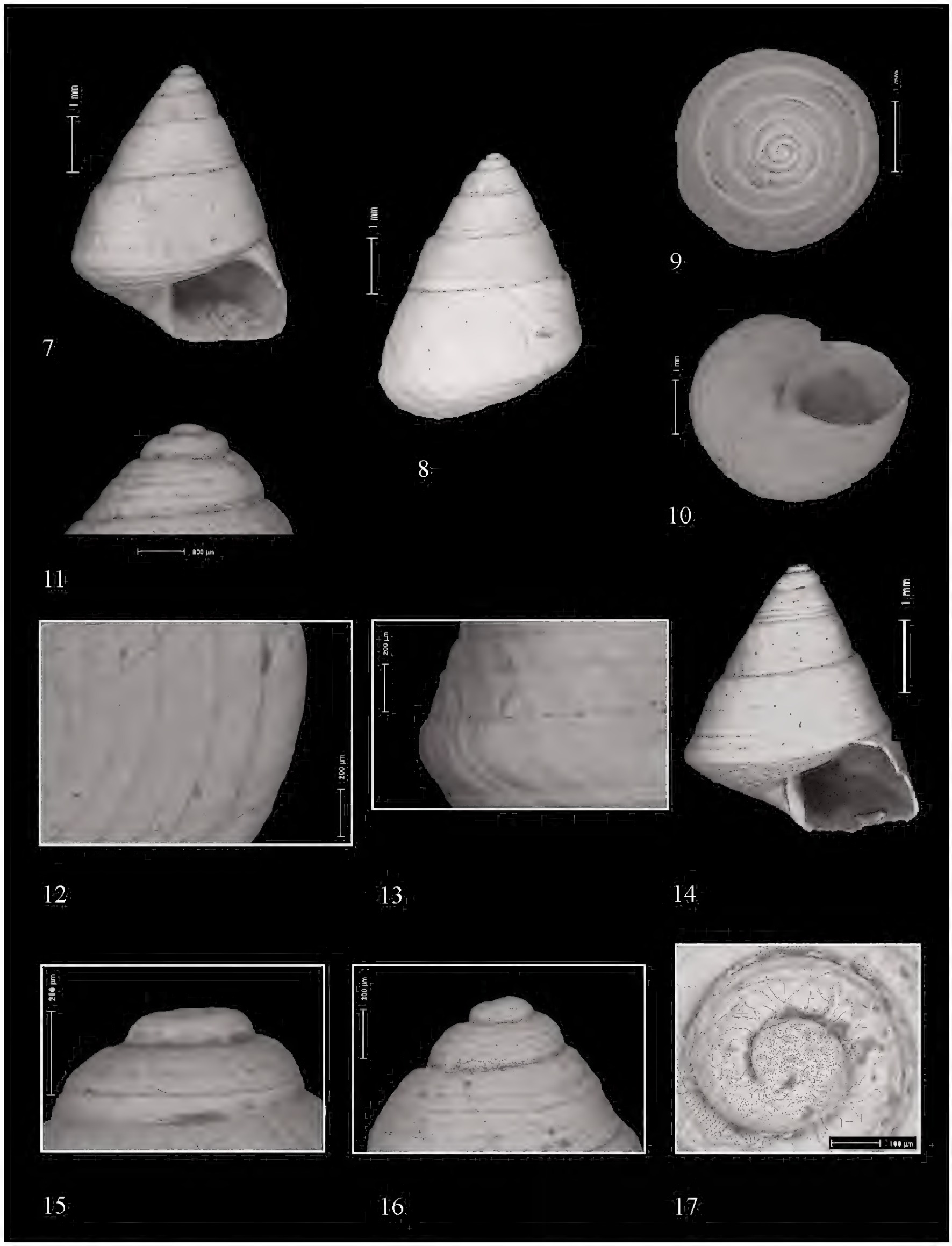
width). Its teleoconch has 4.5 whorls, with 5 flat spiral cords, not regularly spaced, slightly shouldered and ratchet and demarcated by incised spiral lines. Basal cord evident only on the last whorl. Teleoconch surface entirely covered by visible prosocline growth striae. Base slightly convex, umbilicus closed and covered with a whitish callus. Aperture quadrangular, with the columellar callus thickened in the middle portion. Interior of the aperture whitish, nacreous. Colour of protoconch and teleoconch whorls bright reddish, basal cord with yellow wavy lines and base uniformly yellow dotted with red stripes. The most striking difference observed between the holotype and the paratype shells is the teleoconch colour, indicating a great variability of this character.

DISTRIBUTION AND BIOLOGY. This new species is only known from the type locality. *Jujubinus browningleeae* n. sp. were collected while SCUBA diving (30 m depth) on a rocky bottom covered with algae reefs of the Gorringe Bank, 36°35'0"N 11°25'0"W, 130 miles off Cape St. Vincent, Portugal North-Eastern Atlantic.

ETYMOLOGY. This species is named after Mrs Sarah Browning-Lee in recognition of her continu-



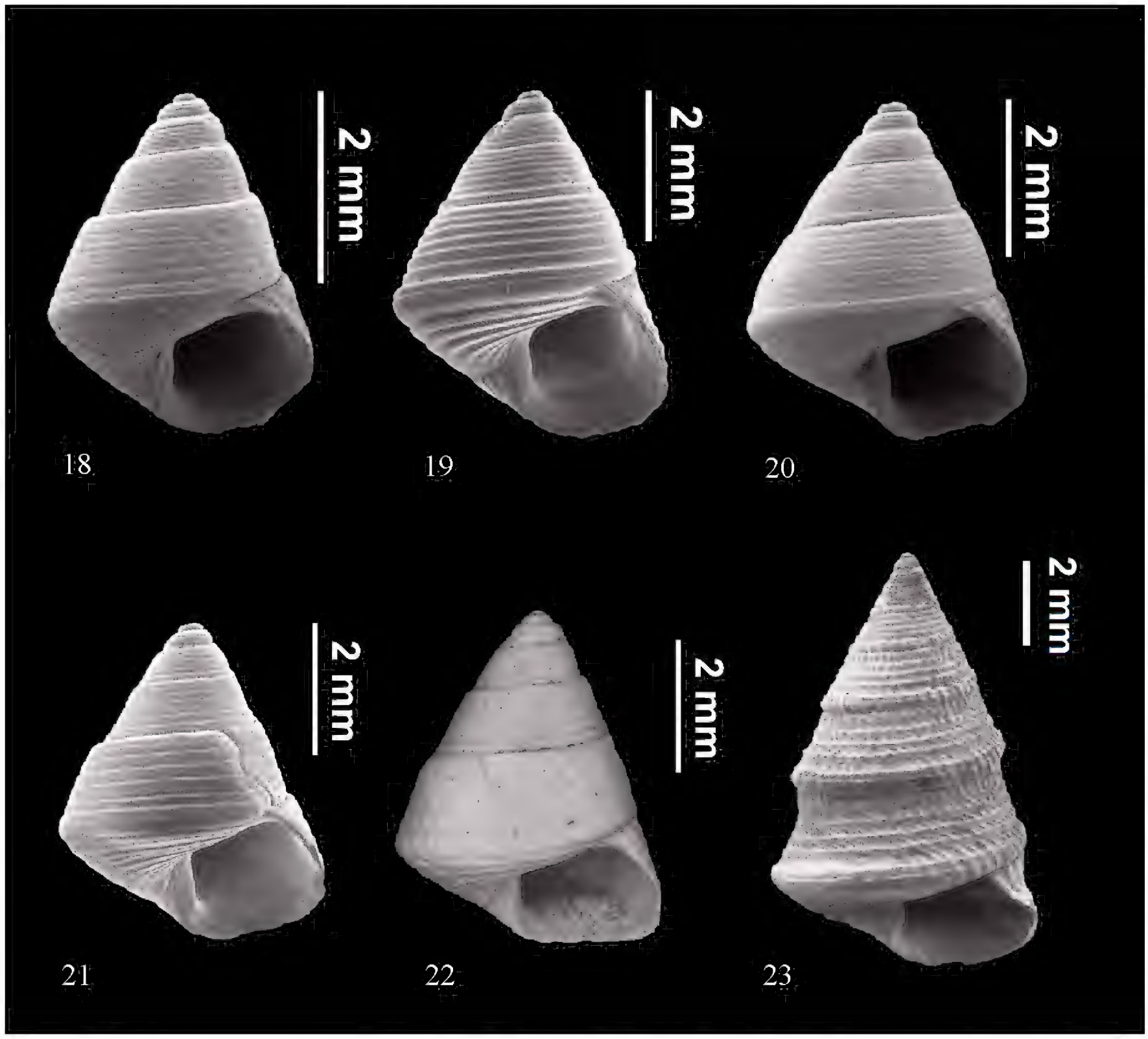
Figures 1–3. *Jujubinus browningleeae* n. sp., holotype (RBINS: I.G.33787/MT.3687), 5.2 mm (H) x 3.8 mm (D), from the type locality (Gorringe Bank, eastern North Atlantic Ocean). Figures 4–6. *Jujubinus browningleeae* n. sp., paratype (FS), 3.8 mm (H) x 3.3 mm (D), from the type locality (Gorringe Bank, eastern North Atlantic Ocean).



Figures 7–13. *Jujubinus browningleeae* n. sp., holotype, SEM analyses, details of the shell. (Gorringe Bank, eastern North Atlantic Ocean). Figures 14–17. *Jujubinus browningleeae* n. sp., paratype (FS), Gorringe Bank, eastern North Atlantic Ocean).

ous efforts over a three year period in collecting sand/sediment samples in the marine environments of Ascension Island for identification of micro molluscs.

REMARKS. The *J. browningleeae* n. sp. (Figs. 1–6, 7–17, 22) differs from all of Mediterranean and Atlantic *Jujubinus* species by its teleoconch sculpture with flat spiral cords, lacking the typical prosocline lamellae in the spiral furrows between cords (Fig. 23), while it resembles the members of the "smooth" group. In fact, the SEM analysis has confirmed the lack of prosocline lamellae in the shells of the new species, and for this reason it can be ascribed to the "smooth" *Jujubinus* complex. The members of this complex share other features, e.g., small size, conical and slightly turriculate outline, teleoconch surface covered by faint prosocline growth striae. In spite of these common mor-



Figures 18–23. *Jujubinus curinii* species complex. Fig. 18: *Jujubinus curinii*, Scilla, 42 m depth, Strait of Messina, Mediterranean Sea (CS-PM). Fig. 19: *Jujubinus eleonorae*, holotype (MNHN 25883), Skerki Bank (37°45'00"N, 10°50'00"E), infralittoral bottom, 37 m depth, Sicily Channel, Mediterranean Sea. Fig. 20: *Jujubinus trilloi*, holotype (MNHN 25882), Talbot Bank (37°30'00"N, 11°40'00"E), infralittoral bottom, 25 m depth, Sicily Channel, Mediterranean Sea. Fig. 21: *Jujubinus alboranensis*, paratype 6, Alboràn Island (35°56'43.99"N, 3°02'03.73"W), 30-37 m depth, amidst Laminaria forest, Mediterranean Sea. Fig. 22: *Jujubinus browningleeae* n. sp., holotype, Gorringe Bank, (36°35'0"N 11°25'0"W), eastern North Atlantic Ocean. Fig. 23: *Jujubinus exasperatus* 10.2 mm (H) x 6.6 mm (D), Giannutri Island (42°15'7.05"N, 11° 5'31.51"E), 10 m depth, on *Posidonia* beds Mediterranean Sea.

phological features, the new species differs from: i) *J. curinii* by its less incised suture, more convex teleoconch whorls and the different colour pattern; ii) *J. eleonorae,* by its more conical shape, the less ratchet spiral sculpture and the different colour pattern; iii) *J. trilloi* by its lower H/D ratio (1.2 vs 1.4, respectively), less convex teleoconch whorls and the different colour pattern; iv) *J. alboranensis* by its smaller size, less turriculate outline and the different colour pattern. The new species is enlarging the number of the components of this "smooth" *Jujubinus* complex, probably originated from a common ancestor. Interestingly, a fossil specimen of *J. curinii* has been found in the geologic stage of "Milazziano" (Tyrrhenian, Pleistocene) located at Capo Milazzo, North-Eastern Sicily (Smriglio et al., 2017). Each species of this complex seems to be endemic and occurs in small geographical spots (Fig. 24). In fact, the new species is known only from the type locality, the Gorringe Bank, North-Eastern Atlantic Ocean (Fig. 24), a high ranked Ecologically or Biologically Significant Area (EBSA), which recently has been included in the list of Sites of Community Importance of Portugal (Ramos et al., 2015). The habitat of seamounts is often very peculiar due to the hydrological and sedimentary dynamics occurring in these submarine environments (Fernández-Palacios et al., 2011; Tittley et al., 2014). These geographical oceanic spots are considered models for marine speciation, due to their distance from the mainland that remained unchanged after their geological formation (Fernández-Palacios et al., 2011; Tittley et al., 2014). Larval dispersion capability represents the only process which ensures to benthic communities colonization and a high level of endemism can be generally observed (Gofas, 2018 and references therein). Currently, *J. browningleeae* n. sp. is the first case of a "smooth" *Jujubinus* occurring in the North-Eastern Atlantic Ocean, while all the other members of the complex are occurring in the Mediterranean Sea. According to the general circulation of the surface water pattern within the Mediterranean Sea, the Atlantic waters enter the Mediterranean through the Strait of Gibraltar, and the inflow is first directed west-eastward along the African coast, mainly due to the Coriolis force (El-Geziry & Bryden, 2010).

It has been calculated that two thirds of the total amount of this Atlantic water current turn Southward through the Strait of Sicily, while one third flows anticlockwise around the Tyrrhenian Sea passing along Sicily and the Italian Peninsula before entering the Channel of Corsica (Bethoux, 1980). Interestingly, the collecting sites of the members of the "smooth" *Jujubinus* complex are overlapping on the surface water current described above and distributed along geographical regions interested by the above mentioned current, suggesting that the complex could be originated from an Atlantic congener ancestor, which entered into the Mediterranean basin and colonized some pe-

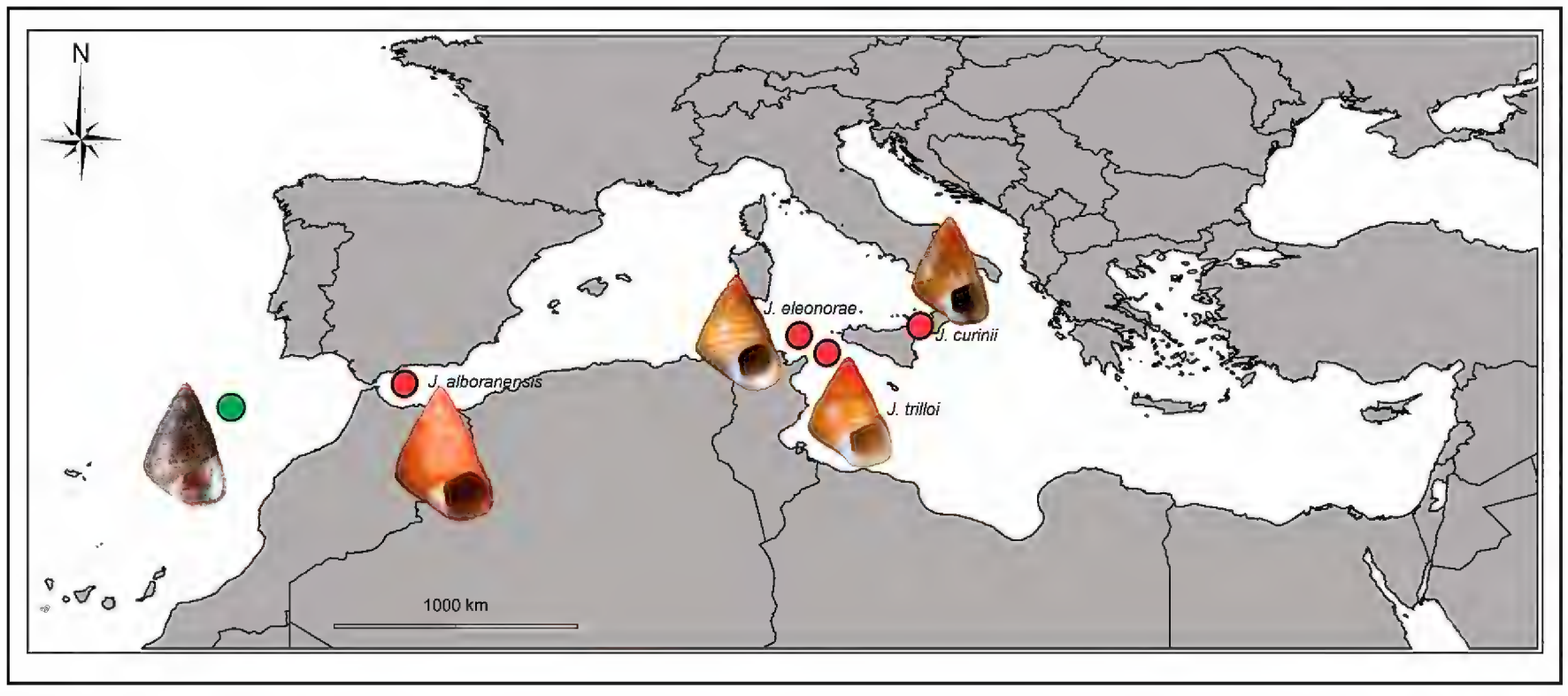


Figure 24. Distribution of *Jujubinus browningleeae* n. sp. (green point) and other species of the *J. curinii* complex (red points).

culiar habitats of the Alboran Sea (*J. alboranensis)*, the Sicily Strait (*J. eleonorae* and *J. trilloi*) and the Messina Strait (*J. curinii*). It is noteworthy to recall that Mediterranean animals of the *Jujubinus* genus, with few exceptions, are generally associated to algal turfs and/or seagrass beds in the photophilic zone, usually at the interdital zone. In this regard, a specimen of *J. trilloi* has been depicted by Trainito & Baldacconi (2014: 178), misidentified as *J. catenatus* Ardovini, 2006. This living individual is grazing on microalgae epiphytes upon *Phyllariopsis brevipes* (C. Agardh) E.C. Henry et G.R. South from the Skerki Bank (E. Trainito, personal communication), suggesting that a possible habitat for the members of the "smooth" *Jujubinus* complex could be marine bottoms hosting kelps (Laminariales). Shells of *J. alboranensis* have been screened out from bioclastic sediment collected amidst *Laminaria* forest at 30-37 m depth (Smriglio et al., 2015). The presence of the kelps *Saccorizha polyschides* (Lightfoot) Batters, *Laminaria rodriguezii* Bornet and *L. ochroleuca* Bachelot de la Pylaie in the Strait of Messina (Drew, 1974; Zampino & Di Martino, 2000) where *J. curinii* occurs, as well as the occurrence of Laminariales in both Skerki and Talbot Banks, where *J. eleonorae* and *J. trilloi* are present, support the hypothesis of a trophic association between the Mediterranean "smooth" *Jujubinus* and kelps. According to Tittley et al. (2014), the kelps *Laminaria ochroleuca* and *Saccorhiza polyschides* occur in the Gorringe Bank, so a possible link between *J. browningleeae* n. sp. and one of these two kelps can be hypothesized as a potential trophic association. A molecular phylogenetic study of this peculiar *Jujubinus* group is advisable to clarify the current relationships among species of the "smooth" *Jujubinus* group and in respect to all other congeners.

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Description of a new species of Coleoptera Melolonthidae Rhizotrogini from Lampedusa Island (Sicily Channel, Italy)

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ABSTRACT The populations of *Pseudoapterogyna* Escalera, 1914 (Coleoptera Melolonthidae Rhizotrogini) from Lampedusa Island (Sicily Channel, Italy) thus far attributed to *P. vorax* (Marseul, 1878) are revised. A morphological comparison with the North African population of this species (type locality: Algeria Batna) allowed us to attribute the populations of Lampedusa to a new species that is herein described. Observations on the biology and ecology of *P. maraventanoi* n. sp. are provided.

KEY WORDS Coleoptera; Melolonthidae; taxonomic; new species.

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INTRODUCTION

Biodiversity surveys conducted in the islands of the Sicily Channel (Central Mediterranean, Italy) and North Africa in recent years allowed to obtain new data and to make some taxonomic observations also on populations already known.

In this work, the *Pseudoapterogyna* Escalera, 1914 populations (Coleoptera Melolonthidae Rhizotrogini) from Lampedusa, known by few records and thus far attributed to *P. vorax* (Marseul, 1878) (Baraud, 1977, 1985, 1992; Arnone et al., 1995; Carpaneto & Piattella, 1995; Smetana & Král, 2006; Ballerio et al., 2010; Sparacio, 2014; Bezděk, 2016), are revised and attributed to a new species which is described below.

ACRONYMS AND ABBREVIATIONS. M. Arnone collection, Palermo, Italy (CMA); A. Ballerio collection, Brescia, Italy (CAB); M. Bellavista collection (CMB); I. Sparacio collection, Palermo, Italy (CIS); Collection of Museum für Naturkunde der Humboldt Universität, Berlin, Germany (ZMHB); Collection of Museo Civico di Storia Naturale "Giacomo Doria", Genova, Italy (MCSNG); Collection of Museum National d'Histoire Naturelle, Paris, France (MNHN); ex/x: specimen/s. Unless otherwise stated, the collector of the beetles in the field is the owner of the collection.

RESULTS

Systematics

Ordo COLEOPTERA Linnaeus, 1758
Familia MELOLONTHIDAE Samouelle, 1819
Subfamilia MELOLONTHINAE Samouelle, 1819
Tribus RHIZOTROGINI Burmeister, 1855
Genus *Pseudoapterogyna* Escalera, 1914

Pseudoapterogyna maraventanoi n. sp.
Figs. 1, 3, 5, 6, 7

TYPE MATERIAL. Holotype male, Italy, Sicily, Lampedusa (Agrigento), 20.XII.2017, leg. G. Mar-

aventano (CIS); idem, 2 males (CIS); idem, 12.I.2018, 1 male and 2 females (CIS); idem, 18.III.2018, 1 male and 1 female (CIS); idem, 1 male (CAB); idem, 1 male and 1 female (CMB); idem, 1 male (MCSNG). Sicily (Agrigento), Lampedusa, 4.VI.1975, 1 male - *Pseudoapterogyna vorax* Mars. J. Baraud det., legit B. Massa (CMA); idem, 1 female, 5.VI.1975 (CMA); Sicilia (Agrigento), Isola di Lampedusa, 15.V.1983, 1 female (CIS). Is. Lampedusa, Cala Galera (AG), 1.V.1991, 1 female, R. Poggi (CMA); idem, 2.XII.1992, 1 male(CMA); Lampedusa, 15.IV.2007, 1 female, legit T. La Mantia (CMA).

OTHER EXAMINED MATERIAL. *Pseudoapterogyna vorax* (Marseul, 1878). Algeria. *Apterogyna vorax* - Algeria Batna - Museum Paris - Coll. Reiche; Museum Paris - Coll. De Marseul - 2842-90; *Rhizotrogus vorax* Mars.; Type; Holotype - *Apterogyna vorax* Marseul, 1878; Holotype - *Pseudoapterogyna vorax* (Marseul, 1878); Holotype (red label); MNHN EC4185; 1 male (MNHN) (Fig. 8). Tunisia. Tunisi dint., aut.-inv. 1881-2, G. e L. Doria, 2 males (MCSNG) (Figs. 2, 4). Libya. Tripolis Quedenfeldt - Tripolis - S2 - *Rhizotrogus Quedenfeldti* Brenske, 1 male (ZMHB, only this specimen that matches with *Rhizotrogus quedenfeldtii* Brenske type, but without any type label). Tripoli - ...; *Rhizotr. tripolitanus* Fm. - Tripoli; Museum Paris - 1906 - Coll. Léon Fairmaire; Holotype (red label); Type (red label); Holotype - *Rhizotrogus tripolitanus* Fairmaire, 1884; MNHN EC9678; 1 male (MNHN) (Fig. 9).

DESCRIPTION OF HOLOTYPE. Male. Lenght 16 mm. Shiny, dorsum reddish-brown; sides of pronotum, antennae, palpi, legs, pubescence, and ventral surface yellowish. Head with big, deep and dense punctation on a finely wrinkled surface, a thin, slightly rised transverse carina and two to three irregular, smooth tubercles. Clypeus slightly emarginated at middle of anterior margin. Antennae 10-segmented, club 3-segmented, slightly longer than funicle (lenght funicle/lenght club = 1.15); scape dilated distally, almost as long as the 2° and 3° segments together. Pronotum slightly convex, transverse, almost twice as wide as long (lenght pronotum/width pronotum = 1.95), sides subrectilinear in the posterior half then narrow and rounded forward, maximum width just before middle, the anterior margin is slightly protruding forward, the posterior margin widely protruding in the back, posterior angles are obtuse and rounded; pronotal sculpturing made of large and shallow punctures irregularly arranged and separated by a surface provided with other very small punctures and with distinct laterobasal depressions; the sides of pronotum bear long and sparse setae, grouped in the central part of the posterior margin; basal bead complete, narrow and punctate. Scutellum triangular with slightly arched sides, and with large, irregular and dense punctures. Elytra subparallel, slightly dilated at apical third, striae wide, well marked and punctuated, interstriae with wide, superficial, irregular punctures, largely confluent on a microreticulated surface; humeral callus visible. Elitral apex with inner apical corner at a right angle. nterior tibiae tridentate, although the basal tooth is hardly visible. Posterior tarsi longer than corresponding tibiae (lenght tarsi/lenght tibiae = 1.8). Posterior tibiae with carina on dorsal side. First posterior tarsomere shorter than the 3° tarsomere. Claws toothed at the base and with a spine well developed. Pygidium rounded at apex, finely wrinkled, micro-reticulated, with small punctures. Metathoracic wings fully developed. Aedeagus with short and strong parameres with pointed apex.

VARIABILITY. Lenght 14–17 mm. Dorsal surface sometimes blackish, with the sides of the pronotum always yellowish. Females are flightless, have a more convex dorsum and elytra more dilated backward, with dorsal punctation sparse and shorter tarsi; posterior tarsi little longer than posterior tibiae.

ETYMOLOGY. The specific epithet, a noun in the genitive singular case, honors Giuseppe Maraventano (Lampedusa, Italy) and his naturalistic passion.

DISTRIBUTION AND BIOLOGY. This new species is endemic to Lampedusa Island (Sicily Channel, Central Mediterranean Sea, Italy). The specimens of the present study were collected in flight or under stones or by digging (G. Maraventano *in verbis*), from December to March. Adults active also in May and June (Arnone et al., 1995; Ballerio et al., 2010).

STATUS AND CONSERVATION. The peculiar biology, few populations, and restricted distribution makes *P. maraventanoi* n. sp. as "Vulnerable", ac-

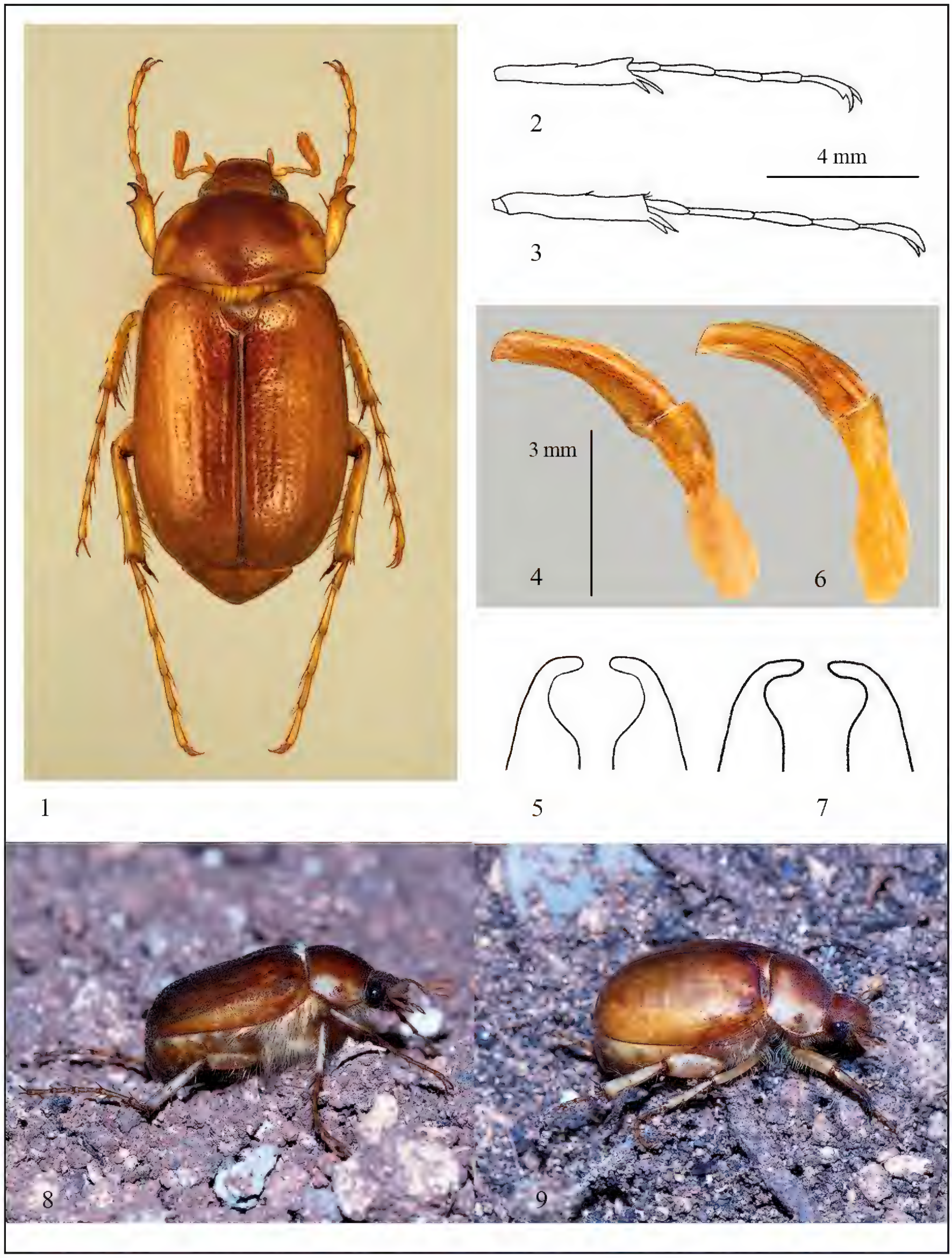

Figure 1. *Pseudoapterogyna maraventanoi* n. sp. from Lampedusa Island (Sicily Channel, Italy), holotype, lenght 16 mm. Figure 2. Posterior tarsi and tibiae of *P. vorax* from Tunisi dint., Tunisia (MCSNG). Figure 3. Idem of *P. maraventanoi* n. sp. Figure 4. Aedeagus of *P. vorax* from Tunisi dint., Tunisia (MCSNG). Figure 5. Idem of *P. maraventanoi* n. sp. Figure 6. *Pseudoapterogyna maraventanoi* n. sp. from Lampedusa Island, male. Figure 7. Idem, female.

cording to the Categories and Criteria of the IUCN Red List of Threatened Species (IUCN, 2017).

COMPARATIVE NOTES. This new species appears distinct morphologically from the neighboring North African populations of *P. vorax*, to which it was attributed, as follows:

1. Dorsal surface opaque, reddish-yellow. Pronotum convex, slightly transverse (lenght pronotum/width pronotum = 1.64), surface between the punctures finely wrinkled. Elitrae with maximum width towards the middle. Medial and posterior tarsi longer than the corresponding tibiae (1.65–1.74). Aedeagus elongate with apex pointed... .....*P. vorax*

-. Dorsal surface shiny, reddish-brown with the pronotum sides yellowish. Pronotum slightly convex, very transverse (lenght pronotum/width pronotum = 1.95), surface between the larger punctures covered by very fine simple punctures. Elitrae with maximum width towards in the apical third. Posterior tarsi longer than corresponding tibiae (1.78–1.85). Aedeagus with parameres shorter and with apex very pointed.....*P. maraventanoi* n. sp.

REMARKS. Recently, we had the opportunity to study a great number of samples thus far attributed to *P. vorax*, that lives in Lampedusa, mentioned in few specimens (Baraud, 1977; Arnone et al., 1995; Sparacio, 2014). This allowed us to distinguish *P. maraventanoi* n. sp. of Lampedusa from *P. vorax* of

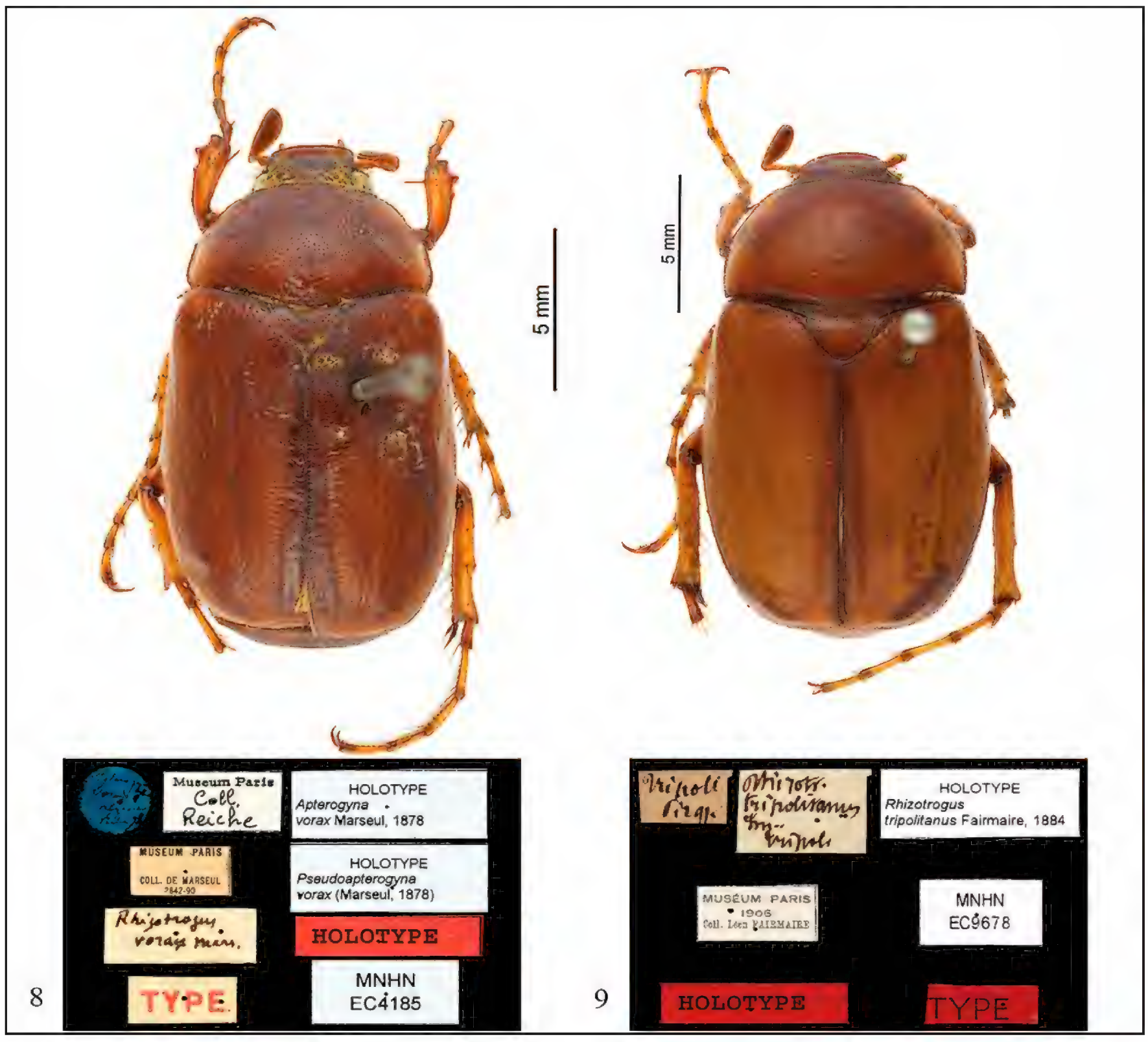

Figure 8. "*Rhizotrogus*" *vorax* Marseul, 1878, holotype, Algeria, Batna (MNHN).
Figure 9. "*Rhizotrogus*" *tripolitanus* Fairmaire, 1884, holotype, Tripoli, Libya (MNHN).

North Africa, of which we have also studied the typical material (Algeria, Batna) and the types of the two synonym recognized for this species: *P. tripolitanus* Fairmaire, 1884 (Libya, Tripoli) e *P. quedenfeldti* Brenske, 1890 (Libya, Tripolis, Kédna), very similar to other North-African populations of *P. vorax*.

Pseudoapterogyna vorax was described for Batna in Algeria (Marseul, 1878) and it is widespread from Morocco to Libya (Baraud, 1977, 1985, 1992; Smetana & Král, 2006; Bezděk, 2016). Baraud (1977) was the first to report the occurrence of this species in Lampedusa (on specimens collected from B. Massa, 4/5.VI.1975), and he stated (Baraud, 1977) that, despite the wide range of this species and the fact that *P. vorax* is "*assez variable*", the specimens he had examined from Lampedusa "*semblent peu different de la forme nominative (Algerie)*".

This species is reported for Lampedusa in all the recent relevant literature (Baraud, 1985, 1992; Carpaneto & Piattella, 1995; Ballerio et al., 2010; Sparacio, 2014; Bezděk, 2016). Arnone et al. (1995) provided new collection data on *P. vorax* in Lampedusa (Cala Galera), while Lo Cascio (2004) and Smetana & Král (2006) reported this species also for Lampione, a very small island located near Lampedusa.

Now, all the reports of *P. vorax* of Lampedusa Island will be reported as of *P. maraventanoi* n. sp.

Finally, I have chosen to keep this new species in the genus *Pseudoapterogyna* (see also Sparacio, 2014) even if I am aware of Coca-Abia's molecular research (2003), which suggests a synonymy of *Pseudoapterogyna* with *Geotrogus* Guérin-Méneville, 1842. Her research, however, must be regarded as preliminary, being based on the examination of only three species out of the over 50 taxa involved (Baraud, 1986; Smetana & Král, 2006; Bezděk, 2016; Miessen et al., 2017).

A broader molecular genetic work, to confirm these preliminary data, is therefore needed in order to confirm Coca-Abia's preliminary results.

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New records of Cracids along a fragmented landscape in Central Mexico (Aves Cracidae)

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ABSTRACT The pava cojolita or crested guan (*Penelope purpurascens* Wagler, 1830) and the great curassow (*Crax rubra* Linnaeus, 1758) (Aves Cracidae) inhabit mature rainforests with low or null perturbation, making them potential indicator species. We report actual records of both species obtained through biodiversity monitoring undertaken in the Experimental Site "Las Margaritas" in the municipality of Hueytamalco at the Sierra Nororiental in the State of Puebla. The presence of both species indicates the importance of the Experimental Site "Las Margaritas" for their distribution within a highly fragmented area.

KEY WORDS Cracid; Campo Experimental Margaritas; Corredor Ecológico de la Sierra Madre Oriental.

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INTRODUCTION

The Cracids (Cracidae) are a family of birds endemic to the neotropics that includes the chachalacas, guans, and curassows, which have a high social and economic value along their distribution (López et al., 2014). However, curassows and guans depend heavily on preserved habitat, which, together with hunting pressure and low reproduction rates (Brooks et al., 1998; Peres, 2000), make them the most threatened bird family in the neotropics (Brooks et al., 2006). Cracid overexploitation has been correlated with human population size and proximity, thus, it is expected that distribution may diminish considerably in these areas (López et al., 2014).

In Mexico, the crested guan (*Penelope purpurascens* Wagler, 1830) and the great curassow (*Crax rubra* Linnaeus, 1758) have high economic and social importance due to their value as game birds since they can reach a weight of 2.4 kg and 4.6 kg respectively (Del Hoyo, 1994; Howell & Webb, 1995). Both species inhabit mature forests or those with low perturbation levels and a high proportion of preserved vegetation (Del Hoyo et al., 1994; Pacheco, 1994; González-García & Martínez-Morales, 2010). The biggest threat to both species is habitat destruction and hunting pressure from local communities (González-García et al., 2012).

In contrast, the great curassow is considered vulnerable despite being distributed from Southern

Tamaulipas, along the Mexican Gulf, to western Colombia and western Ecuador, as it has been extirpated from large parts of its distribution (Howell & Webb, 1995; Del Hoyo & Motis, 2004; Hernández-Pérez et al., 2014), particularly: *C. rubra rubra* from humid forests from eastern Mexico to western Ecuador, and *C. rubra griscomi* Nelson, 1926 from Cozumel Island (off Yucatán coast of Mexico). Under Mexican legislation, both species are considered as threatened (SEMARNAT, 2010, 2011).

In contrast, the crested guan is considered as a low-risk species by the IUCN due to its widespread distribution that goes from southern Tamaulipas to northern Ecuador (BirdLife International, 2016), particularly: *P. purpurascens purpurascens* from Humid forests of Mexico to Honduras and Nicaragua, *P. purpurascens aequatorialis* (Salvadori & Festa, 1900) from southern Honduras and Nicaragua to western Colombia and southwestern Ecuador, *P. purpurascens brunnescens* (Hellmayr & Conover, 1932) from northern Colombia to eastern Venezuela. However, their populations are slowly diminishing (BirdLife International, 2016).

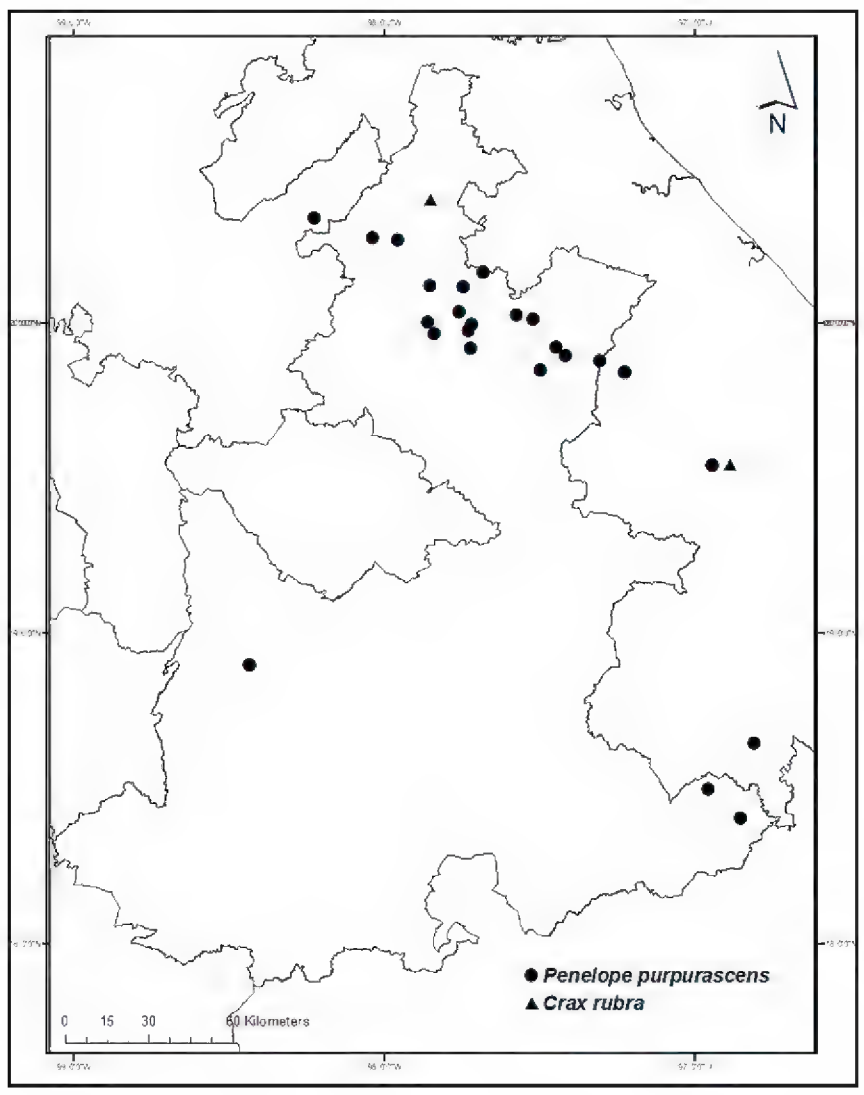

Figure 1. Records of the great currasow (*Crax rubra*) and the crested guan (*Penelope purpurascens*).

To produce effective management and conservation plans for populations of both species, it is necessary to generate updated high-resolution information about their distribution (Hernández-Pérez et al., 2014), as it is considered that viable populations are going to be reduced to protected areas or those with sufficient forest cover (Pérez-Irineo & Santos-Moreno, 2017). In this note, we present updated information about the presence and distribution of both species in a highly fragmented zone.

MATERIAL AND METHODS

Fieldwork was carried out in the Sitio Experimental Las Margaritas which is overseen by the National Institute of Forestry, Agricultural and Livestock Research (INIFAP). It is located in the municipality of Hueytamalco, Puebla in Central Mexico, and it covers a surface of 2,523 ha and an average altitude of 500 m asl (20°00'05.22"N, 97° 18'28.31"W) (Fig. 1). Originally, the area was used for livestock research, however, currently there are four main land uses: grasslands (300 ha), bamboo plantations (*Guadua aculeata* E. Fourn.) (355 ha), secondary forest in different successional stages (1,568 ha), and preserved rainforest (300 ha) (INEGI, 2007). The region has abundant rains during most of the year and a dry season during May-June. Average precipitation is 3,153 mm, and the average temperature is 21°C (García, 2004). Wildlife was surveyed during two periods, one in 2009 and 2010, in which we used six camera stations, and a second period in 2016 and 2017, in which we used 47 stations. In both cases, the cameras were set randomly along roads, trails and water bodies considering a minimum distance of 500 m between them. Each station consisted of a camera trap (Scout Guard, Wildview, Bushnell) set at a height of 50 cm above ground. They were active in a 24 hours period, and were checked periodically and rotated every month. During both survey periods, we worked in sections dominated by rainforest with an average altitude of 412 m asl.

An index of relative abundance (RA) was calculated as the number of independent records obtained per camera nights during the sampling period.

RESULTS

Systematics

Classis AVES Linnaeus, 1758
Ordo GALLIFORMES Temminck, 1820
Familia CRACIDAE Rafinesque, 1815
Genus *Crax* Linnaeus, 1758

Crax rubra Linnaeus, 1758

EXAMINED MATERIAL. Sitio Experimental Las Margaritas, Hueytamalco municipality in Central Mexico (20°00'05.22" N, 97°18'28.31" W), Lorena Silverio Polo and Eric Ramírez, 5 pictures.

REMARKS. The pictures clearly depict a cracid of large size, black color with a curly crest, and a yellow knob on its bill. We based our identifications on morphological characters, all of which fit the description of *Crax rubra* present in the "Birds of Mexico and Central America" field guide (Van Perlo, 2006).

Genus *Penelope* Merrem, 1786

Penelope purpurascens Wagler, 1830

EXAMINED MATERIAL. Sitio Experimental Las Margaritas, Hueytamalco municipality in Central Mexico (20°00'05.22"N, 97°18'28.31"W), Lorena Silverio Polo, 1 picture.

REMARKS. The pictures clearly depict a cracid of large size, with bluish bare skin on the face, a bare red dewlap on the throat, with a dark brown plumage and red legs which fit the description of *Penelope purpurascens* present in the "Birds of Mexico and Central America" field guide (Van Perlo, 2006).

DISCUSSION

We accumulated a total of 195 camera nights during the first sampling period (2009–2010), during which we obtained five records of the great curassow (*Crax rubra*) (RA= 0.025) (Fig. 2) and none of the crested guan (*Penelope purpurascens*) (Fig. 3). During the second period (2016–2017) we accumulated a total of 1,089 camera nights and 98 unique records in 16 sites of the great curassow (RA=0.089), four chachalaca (*Ortalis* spp.) records (RA=0.003), and just one of the *crested guan* (RA=0.001). Other species recorded in the camera traps were white-tailed deer, *Odocoileus virginianus* (Zimmermann, 1780), raccoons, *Procyon lotor* (Linnaeus, 1758), and armadillo.

Although both species were previously reported in the region during interviews with local communities in 2003 (Cossió, 2007), there was no field information on their abundance or response to habitat loss despite it being one of the main threats to their survival (Brooks & Strahl, 2006).

Figure 2. Records of the great currasow (*Crax rubra*).
Figure 3. Records of crested guan (*Penelope purpurascens*).

This is of great importance, as between 2003 and 2016 there was an increase of 5,659 ha in the agricultural surface in the region (SIAP, 2018). Furthermore, communities where Cossio (2007) undertook her fieldwork reported active use of both species, and they considered that the crested guan was scarce and that populations were diminishing while the great curassow was absent in some areas. In the case of the crested guan, the closest records can be found at 16.5 km and 22.62 km to the southeast (Teziutlán) and 16.10 km to the southwest (Hueyapan) (Gonzalez-García et al., 2012; GBIF, 2016), while the closest record for the great curassow corresponds to a sighting from 1942 in the municipality of Huauchinango, which is located at 69.75 km (eBird, 2018).

Despite the fact that previous studies have estimated the density of both species along their range, such estimates are not considered a credible predictor of local density, as this may vary due to differences in habitat structure and variation in resource distribution or abundance (Kattan et al., 2016). Additionally, areas of high density do not necessarily represent suitable habitats for species on account of the fact that bird species may become established in marginal habitats due to a variety of factors (Kattan et al., 2016). Nevertheless, for some species, as the great curassow, density reflects hunting pressure in the area (Baur, 2008). For that species, there are densities of 1.4 birds/km^2 in protected areas (Eisermann, 2004) while in fragmented areas densities vary from 0.4–1.2 birds/km^2 (Vaughan, 1983; McCoy, 1997) which could be due hunting effects or habitat loss. Similarly, for the crested guan, densities in protected areas range from 6–28 birds/km^2 and in areas open to hunting they vary between 2 and 7 birds/km^2 (Baur, 2008). Since relative abundance can often be related to density, we consider that our results are representative of values typical of hunted areas, as communities in the area actively use both species. It is noteworthy that in CE Margaritas, contrary to other areas where both species are present, the abundance of the great curassow is higher than that of the crested guan (Lowery & Dalquest, 1951; Schaldach, 1963, 1969; Vannini & Rockstroh, 1997) which could be due to the altitude at which records were obtained. However, we found consistency with previous studies that noted a high frequency of solitary individuals and a morning activity pattern (Pérez-Irineo & Santos-Moreno, 2017).

The principal threat for the great curassow is habitat loss (Brooks & Strahl, 2000; Rios & Munoz, 2006), as it generates fragmented populations (Howell & Webb, 1995; Brooks & Strahl, 2000; Rios & Munoz, 2006). In our study area, fragmentation has increased due to conversion of rainforest to orange plantations that cover near half of the agricultural surface in the region (42.4%) (Soler Montcouquiol & Hernández Plascencia, 2005). Although the great curassow can withstand certain levels of habitat alteration, the species is sensitive to changes in vegetation structure (McCoy, 1997; Radachowsky et al., 2004). Thus, this type of agricultural development might favor the isolation of remnant populations. Furthermore, closeness to human settlements promotes high levels of hunting (Silva & Strahl, 1991), as both species represent an important source of protein (Baur, 2008). However, there is no up-to-date information on hunting in the area or on habitat alterations that may occur as the species is considered an effective seed disperser (Howe, 1993; Pacheco, 1994), and a reduction in its density may result in changes in forest structure (Moreira et al., 2017).

The records obtained in the CE "Las Margaritas" during both seasons are of great significance as they indicate that the species is still present in the area and that its abundance has not varied despite constant threats. However, the high fragmentation levels in the area prevent the formation of corridors between remnant populations. Thus, available information could help generate a conservation strategy that would promote patch connectivity in such a way that it favors altitudinal and temporal migration among patches (Chaves-Campos, 2003).

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The genus *Crispatotrochus* Tenison-Woods, 1878 (Anthozoa Scleractinia) from the Mediterranean Pliocene

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ABSTRACT A undetermined species of *Crispatotrochus* Tenison-Woods, 1878 (Anthozoa Scleractinia) from the Early Pliocene of Monte Calcinaio, in Radicofani basin (Italy, Toscana, Siena,) is herein described. This genus is still recorded worldwide, but is unknown in the eastern Atlantic and Mediterranean Sea. This is the first report of this genus from the Mediterranean Pliocene.

KEY WORDS Early Pliocene; Tuscany, Monte Calcinaio; Scleractinian; Caryophyllidae; *Crispatotrochus*.

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INTRODUCTION

The Pliocene scleractinian corals from the Siena area (Central Italy) was described by Spadini (2015, 2016). Although most of this scleractinian fauna, which includes more than fifty species, is well known, a part of it is still waiting to be classified. In particular, the studied species is now assigned to the *Crispatotrochus* Tenison-Woods, 1878, a genus of solitary scleractinian Caryophyllidae Gray 1847 found only in the Pliocene outcrops of Monte Calcinaio (Siena).

The scleractinian fauna of Monte Calcinaio in the Radicofani basin is characterized by numerous species belonging to genera reported for the first time from the Mediterranean Pliocene (*Bathelia* Moseley, 1881; *Coenosmilia* Pourtalès, 1874; *Pourtalosmilia* Duncan, 1884; *Tethocyathus* Kühn, 1933; *Monomyces* Ehrenberg, 1834) or others considered doubtful until now (*Coenocyathus* Milne Edwards et Haime, 1848; *Stenocyathus* Pourtalès, 1874) (Spadini, 2015, 2016). These genera currently include species that live on hard or detrital substrates from infralittoral to circalittoral and in some cases bathyal environments.

Conversely, in the outcrops of Monte Calcinaio, species associated with soft clay sediments that compose the group of dominant corals in other Sienese deposits (and more generally in the Mediterranean Pliocene) are lacking or very rare. These species belong to the genera/subgenera *Caryophyllia* (*Ceratocyathus*) Seguenza, 1864, *Ceratotrochus* Milne Edwards et Haime, 1848, *Flabellum* Lesson, 1831 and *Balanophyllia* (*Eupsammia*) Milne Edwards et Haime, 1848 (Spadini, 2015).

This short note analyses specimens of a species associated with hard substrates, which does not appear in the Pliocene or Recent fauna of the Mediterranean Sea, but can be compared with certain species now living in the Atlantic and Indo-Pacific Oceans (Kitahara & Cairns, 2008). The fundamental morphological characters of these specimens, broad base, columella with an irregular group of elements, and no pali and endotheca, suggest that this species belongs to the genus *Crispatotrochus* of the family Caryophyllidae.

This is the first report of this genus from the Mediterranean Pliocene.

MATERIAL AND METHODS

The material studied in the present report was found at a site on Monte Calcinaio (altitude 732 m; 52°54'55"N, 11°48'59"E) near the Radicofani district in the Radicofani basin (Tuscany, Italy) (Figs. 1, 2). Pliocene sedimentation in this area started at the beginning of the Pliocene (Zanclean) and lasted until the Early Piacentian. In the central part of the sedimentation basin, it developed mostly in a neritic environment and sediments, for the most part consist of deep-sea clays with sandy-conglomeratic intercalations, attributable to the *G. margaritae* Bolli et Bermudez, 1965 biozone (Liotta, 1996; Pascucci et al., 2006, Spadini, 2016).

ABBREVATION AND ACRONYMS. The following abbreviations are used in the text: D = maximum calicular diameter; d = minimum calicular diameter; H = maximum height; Sx = septa of cycle x (S1, S2, etc.); MUSNAF = Museo di Storia Naturale dell'Accademia dei Fisiocritici, Siena.

RESULTS

Systematics

Classis ANTHOZOA Ehrenberg, 1834
Subclassis HEXACORALLIA Haeckel, 1866
Ordo SCLERACTINIA Bourne, 1900
Familia CARYOPHYLLIDAE Gray, 1847

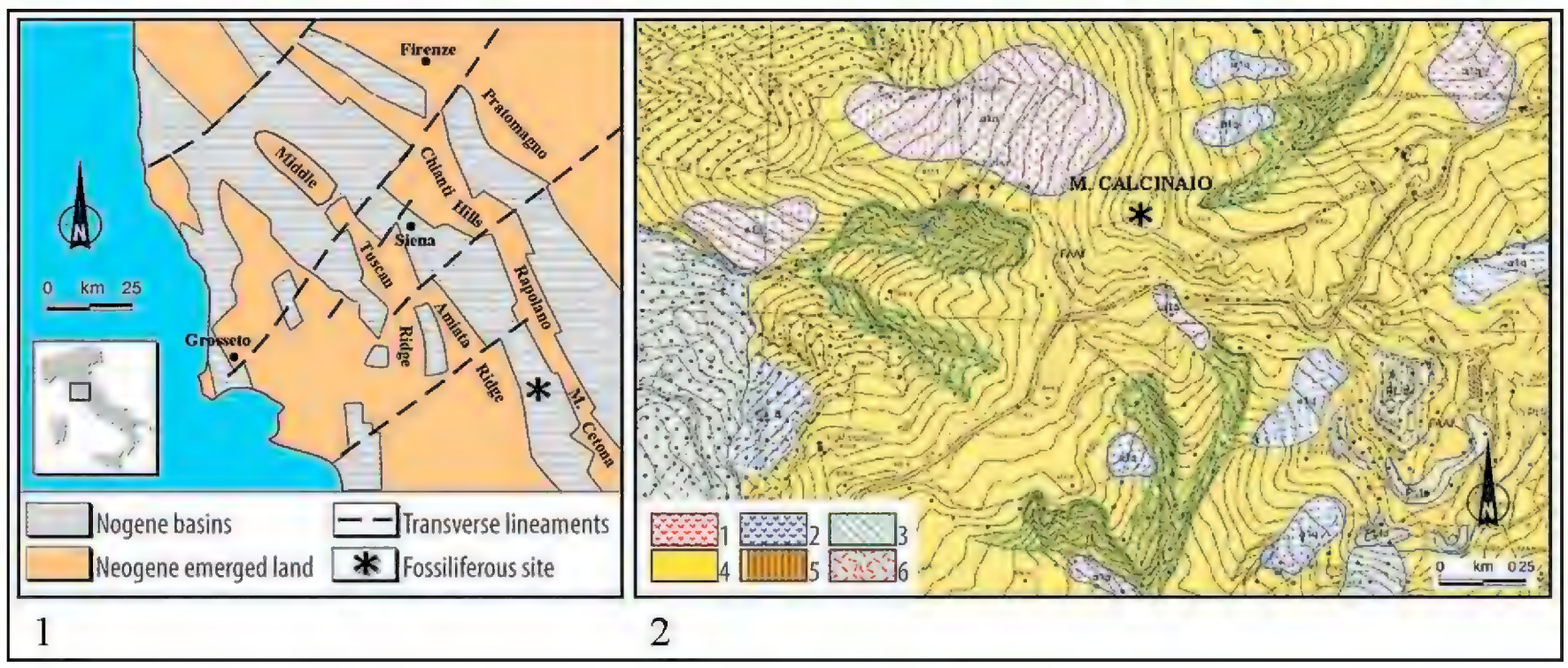
Genus ***Crispatotrochus*** Tenison-Woods, 1878

TYPE SPECIES. *Crispatotrochus inortatus* Tenison-Woods, 1878, by monotypy.

DIAGNOSIS. Corallum solitary, ceratoid to turbinate, usually attached. Septal symmetry hexameral or decameral. Septotheca costate or bearing transverse ridges. Pali absent. Columella fascicular composed of twisted elements (Kitahara & Cairns, 2008).

DISTRIBUTION. The genus *Crispatotrochus* is recorded worldwide with numerous Recent species, but is unknown in the eastern Atlantic and Mediterranean Sea (Kitahara & Cairns, 2008). It occurs at depths from 82 to 2,505 m.

STRATIGRAPHIC DISTRIBUTION. *Crispatotrochus* is known from the Paleogene to Recent with six fossil species (Stolarski, 1996).



Figures 1, 2. Location of the studied outcrop. Fig. 1. Simplified structural setting of the studied area (Tuscany, Italy) showing the Monte Calcinaio fossiliferous site in the Radicofani basin (asterisk). Modified from Spadini & Manganelli, 2016. Fig. 2. Simplified geological sketch of the area of Monte Calcinaio (asterisk). Modified from the Carta Tecnica Regionale 321060 (downloaded from http://www502.regione.toscana.it/geoscopio/cartoteca.html). 1: active landslide; 2: dormant landslide; 3: badlands; 4: Zanclean-Piacentian fossiliferous clays and silty clays; 5: Zanclean-Piacentian polygenic breccias; 6: Holocenic slope deposits.

REMARKS. *Crispatotrochus* (= *Cyathoceras* Moseley, 1881; type species *Cyathoceras cornu* Moseley, 1881) is closely related to *Caryophyllia*, but is devoid of pali. It differs from *Labyrinthocyathus* Cairns, 1979 in columellar characters. *Psammocyathus* Chevalier 1963 (type species *Psammocyathus pirenaïcum* Chevalier, 1963) described as a subgenus of *Cyathoceras,* has a columella consisting of anastomosing paliform lobes and is very similar to *Crispatotrochus*, but Cauhzac & Chaix (1996) consider *Psammocyathus pirenaïcum* to be a synonym of the colonial oculinid *Diplohelia conferta* (Milne-Edwards et Haime, 1850).

Vaughan & Wells (1843) and Wells (1956) consider *Crispatotrochus* synonymous with *Ceratotrochus* Milne Edwards et Haime, 1848. Chevalier (1987) considered it a subgenus of *Edwardsotrochus* Chevalier, 1961, different from *Cyathoceras*, but a senior synonym of *Labyrinthocyathus*.

Conversely, Cairns (1991) considers *Cyathoceras* synonymous with *Crispatotrochus*, which has priority (Cairns, 1991), and *Labyrinthocyathus* as a separate genus.

In this short note, in agreement with Cairns (1991), it is sustained that *Crispatotrochus* (= *Cyathoceras*) differs from *Labyrinthocyathus* in columellar character, while *Psammocyathus* remains of uncertain generic status.

The genus *Crispatotrochus* is recorded worldwide with about 13 valid Recent species (Kitahara & Cairns, 2008) and is known from the Paleogene (Stolarski, 1996) with six fossil species. Two of them, *C. tortonensis* (Chevalier, 1961) from the Tortonian of Moncucco (Italy) and *C. demarcqi* Chevalier, 1963, from the Miocene of France, have four septal cycles. *Crispatotrochus antarcticus* Stolarski, 1996, from the Antarctic Paleogene has four cycles and some fifth-cycle septa. *Crispatotrochus periallus* Squires, 1962, from the Oligocene of New Zealand and *C. rubescens* (Squires, 1958) from the Pliocene of New Zealand have five cycles of septa. Finally, *C. galloprovincialis* Chevalier et Demarcq, 1964, from the Miocene of France has decameral symmetry.

The species assigned to *Crispatotrochus* are characterized by a columella with a variable number of twisted elements. However, some species classified in this genus have a columella composed of variably fused ribbons and small buds. Among living species, *C. irregularis* from the Antarctic has a columella composed of closely united, poorly defined, twisted ribbons and *C. septumdentatus* Kitahara et Cairns, 2008, from New Caledonia has a columella composed of closely grouped ribbons, fused into a solid mass (Kitahara & Cairns, 2008). Among fossil species, *C. antarcticus* Stolarski, 1996, shows fused columellar elements similar to the columella of species of the genus *Labirintocyathus* (Stolarski, 1996). Even *C. demarcqi* (Chevalier et Demarcq, 1964) and *C. galloprovincialis* (Chevalier et Demarcq, 1964) from the Miocene of France have a columella with vertically arranged lobes.

Therefore, given the columellar variability in *Crispatotrochus* species, it is suggested that the Monte Calcinaio specimens can be included in this genus.

Crispatotrochus sp. (Figs. 3–6)

EXAMINED MATERIAL. Monte Calcinaio (Siena, Italy), material collected by the author in the years

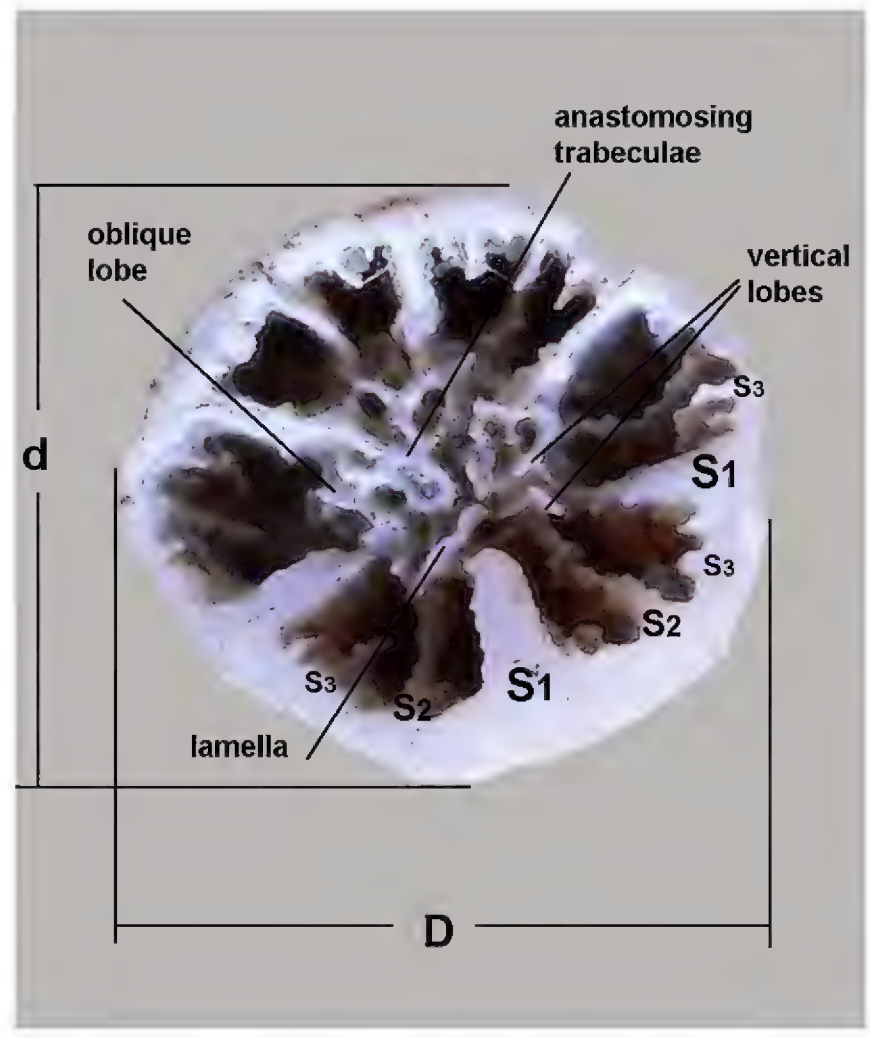
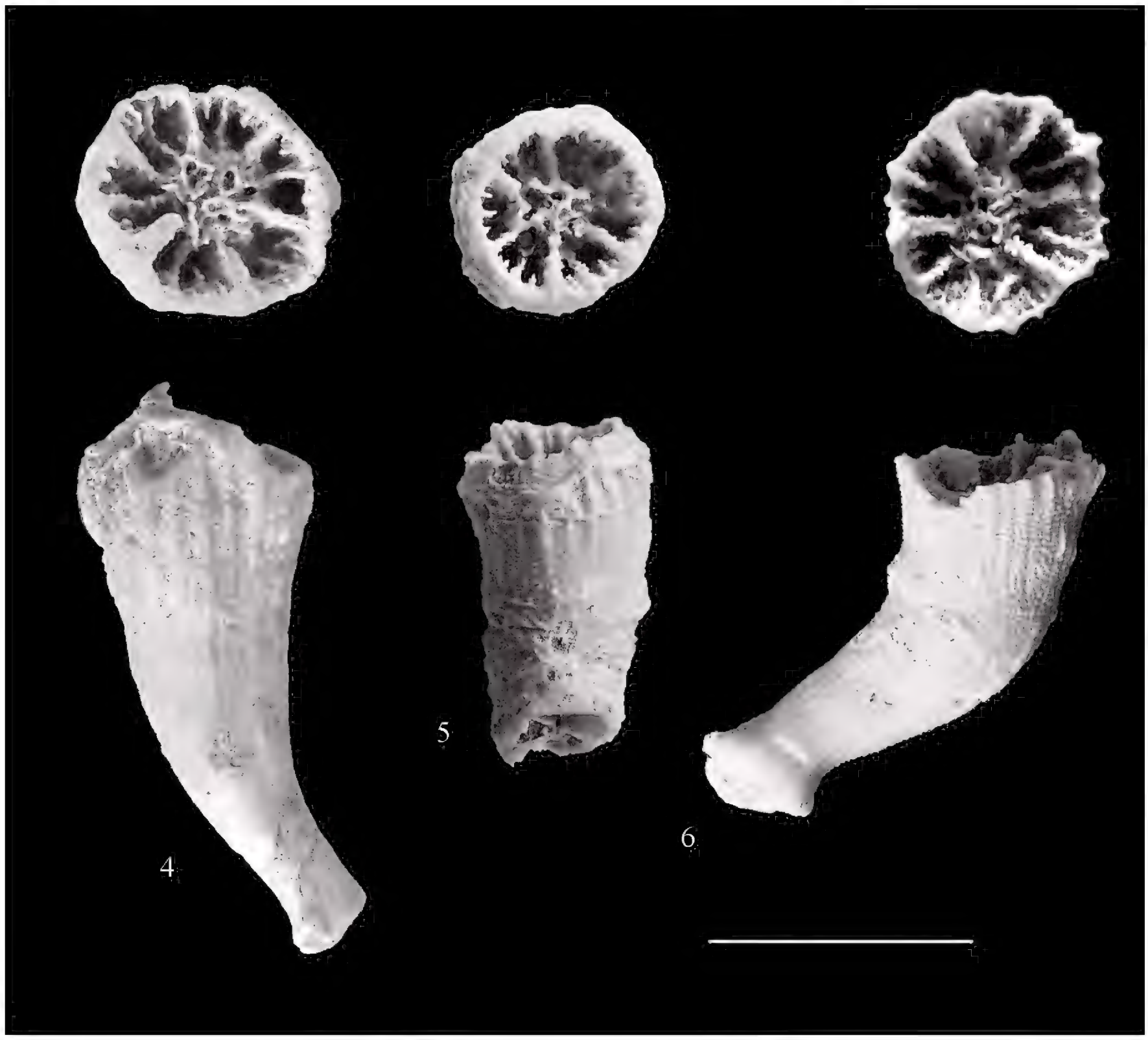


Figure 3. Calice of *Crispatotrochus* sp. from Monte Calcinaio (Siena, Italy). For explanation of the terms used in this figure, see Material and Methods.



Figures 4–6. *Crispatotrochus* sp., Zanclean of Monte Calcinaio (Siena, Italy). Scale bar = 5 mm.

2010–1015. Two complete and two incomplete specimens and some fragments. The materials are kept in the Museo di Storia Naturale dell'Accademia dei Fisiocritici di Siena, Geo-Paleontological Collections. Dimensions: specimen 1: H: 12.9, D: 4.3, d: 3.6, number of septa: 40; specimen 2: H: 9.8, D: 4.2, d: 4, number of septa: 40; specimen 3: H: 10.9, D: 4.7, d: 4.6, number of septa: 28; specimen 4: H: 7.3, D: 5.6, d: 5.3, number of septa: 24.

DESCRIPTION. Corallum ceratoid, elongated, curved, slightly flared distally. Encrusting base, slightly enlarged. Theca costate, consisting of broad, slightly convex costae, separated by very fine shallow intercostal grooves and uniformly covered in small granules. Circular or slightly elliptical calice with partially preserved edge. Four incomplete cycles of septa, arranged in six systems, up to a maximum of 40 septa in large specimens. S1 very compact, slightly exserted, with straight axial edges that reach and merge with the columella. S2 are less exserted, also with straight axial edges that merge with the columella deeper than S1. S3 are wide around a quarter or half of calice diameter and S4 are rudimentary and very fine. Sometimes S4 bear short upward-curving lobes. The ornamentation of the inner face of the septa consists of granules of unknown form and constitution.

Fossa shallow with circular or elliptical columella, composed of fine grouped ribbons, more or less fused together by non twisted, vertical, or more rarely oblique lobes and lamellae, irregularly disposed on the columella (Fig. 3).

REMARKS. *Crispatotrochus* sp. of Monte Calcinaio is distinguished from its congeners, which have four incomplete cycles of hexamerally arranged septa, by thick S1 and less thick S2.

Two of the incomplete specimens examined lack a base, while two other specimens are attached via thick pedicels and encrusting bases (Figs. 5, 6).

In specimens with 40 septa (Fig. 3), the columella consists of interconnected lamellae, like in *Psammocyathus*, but one of these specimens shows variably evident irregular buds or small lobes arranged vertically or obliquely.

The presence of an undescribed species of the genus *Crispatotrochus* from the Pliocene of Monte Calcinaio, with other undetermined species belonging to genera hitherto unknown from the Mediterranean Pliocene (Spadini, 2015, 2016), is of considerable importance for reconstructing events in the early Pliocene. It is further evidence that the Pliocene history of scleractinian azooxanthellate corals of the Mediterranean Sea is still poorly understood.

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Contribution to the bats knowledge of the Pacaya Samiria National Reserve, Loreto, Peru (Mammalia Chiroptera)

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ABSTRACT

Bats species richness (Mammalia Chiroptera) in Neotropical localities is generally higher than that of any other group of mammals. Surveys of local bat assemblages may provide useful data for conservation management plans. This paper presents bat records based on a chiropterological collection obtained during a preliminary multi-taxa survey (ECOMUSA Project) conducted by the Museo di Storia Naturale di Carmagnola (Torino, Italy) and the Universidad Nacional de la Amazonia Peruana, Iquitos (Loreto, Peru) in the Pacaya Samiria National Reserve (PSNR), where information on bats are scarce, with the aim of contributing a preliminary check of the bats listed between the Marañón, Ucayali, and Amazon rivers south of Iquitos. The survey was conducted from March 14 to March 24, 2002, in two sites of the PSNR. 74 bats of 19 species (18 Phyllostomidae, 1 Emballonuridae) were collected. The most collected species was *Sturnira lilium,* which makes up 28% of the captured bats, followed by *Carollia perspicillata*. In general, the composition of the bat community detected during this short survey in PSNR corresponds to the typical composition of neotropical rainforests. Despite the short duration of the survey, the collected data contributes to the knowledge of bats in PSNR and in the area between the Marañón, Ucayali, and Amazon rivers south of Iquitos, and represents the first record of *Rhynchonycteris naso* in this area.

KEY WORDS Chiroptera; Neotropical bats; Peruvian Amazon Forest.

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INTRODUCTION

With more than 1,300 extant species, bats (Chiroptera) form the second largest mammalian order (Voigt & Kingston, 2016) and constitute the greatest diversity of mammals (Sosa et al., 2008). Within the neotropical region, Peru is one of the countries with the greatest bat diversity with its 165 species (Pacheco et al., 2009). Of these, 97 species are reported in the Loreto province (Fernández-Arellano & Torres-Vásquez, 2013), where the area around Iquitos, along the Marañón and Ucayali rivers, is one of the most studied (Ascorra et al., 1993; Klingbeil & Willig, 2010; Mori et al., 2012; Fernández-Arellano & Torres-Vásquez, 2013).

The Pacaya-Samiria National Reserve (PSNR) is the largest protected area in the Peruvian Amazon, covering over 2 million hectares. It is located south of the Amazon/Marañón River, and east of the Ucayali, which are two important biogeographical barriers. Nevertheless, the information about bats in the PSNR is scarce and related mainly to museum specimens (Ruelas, 2017).

This paper presents bat records based on a chiropterological collection obtained during a preliminary multi-taxa survey (ECOMUSA Project) conducted by the Museo di Storia Naturale di Carmagnola (Torino, Italy) and the Universidad Nacional de la Amazonia Peruana, Iquitos (Loreto, Peru) in the Pacaya Samiria National Reserve (PSNR).

The purpose of this paper is to contribute to a preliminary check of the list of bats between the Marañón, Ucayali, and Amazon Rivers south of Iquitos.

MATERIAL AND METHODS

Study area

The survey was conducted from March 14 to March 24, 2002 in two sites (XX de Enero and Yarina) in the Pacaya Samiria National Reserve (Loreto, Peru), along the Rio Yanayacu-Pucate (Fig. 1).

XX de Enero (4°39'S, 73°49'W; 102 m a.s.l., March 14 and March 21–24). This is a small village on the right bank of the Rio Yanayacu-Pucate, about 1 km upstream from its confluence with the Marañón River. Habitats near the village where field work was conducted include orchards rather degraded varzea forest behind the village, flooded varzea forest (surveyed by canoe), and flooded *Cecropia* dominated second growth.

Yarina (4°45'S, 73°59'W; 110 m a.s.l., March 15–21). This is another small village on the right bank of the Yanayacu-Pucate, about 20 km upstream from XX de Enero. Human impact is much more limited here, and there are no other settlements on the Yanayacu-Pucate upstream from Yarina. Most of the field work here was concentrated in varzea and transitional forest, about 1 Km south of the village.

Data collection and analysis

Bats were captured in mist nets set from ground level to 2.5 meters high, similarly to those used mainly for ornithological research (Janni et al., 2008). Mist-net lines of 10–20 nets (using 12-meter nets) spaced about 50 meters each, were open at dawn, closed rapidly after sunset, and were used for a total of 570 net-hours at Yarina and 300 net-hours at XX de Enero. Field work was carried out under a specific permit from the "Instituto Nacional de Recursos Naturales, Ministero de Agricultura, Republica del Perù" n° 01 C/C-2002- INRENA-DGANP of the 12/3/02. The zoological specimens are held in the Museo Civico di Storia Naturale of Carmagnola, Italy (MCCI) and at the Universitad de la Amazonia Peruana, Peru (UNAP).

This work is based only on voucher specimens preserved in MCCI for which a clear identification was possible, while the bats captured and subsequently released were excluded, because identification was uncertain in the field.

Specimens preserved were sexed and identified using mainly Lopez-Baucells et al. (2016) integrated with Aguirre et al. (2009) and Diaz et al. (2011). For the species of the genus *Carollia* Gray, 1838 the indication provided by Ruelas (2017) was used. For each bat, the following biometric measurements used for identification were taken: forearm, fifth finger, and tibia. For the specimens of the *Carollia* genera, given the difficulty of identification, the upper molar canine length was also measured.

When possible, the reproductive status of the captured females was assessed through observation of the nipples (Racey, 2009).

The data of this work has been integrated with similar research conducted within a radius of 100 km from the investigated locations (Klingbeil & Willig, 2010; Díaz, 2011; Mori et al., 2012; Linares-Palomino et al., 2013; Fernández-Arellano & Torres-Vásquez, 2013), in order to provide a preliminary bat checklist of the Marañón, Ucayali, and Amazon River areas south of Iquitos.

RESULTS

The examined specimens represent 19 species of bats (18 Phyllostomidae, 1 Emballonuridae), 34 males and 40 females (Table 1). Phyllostomidae are represented by five subfamilies: Carolliinae, Glossophaginae, Lonchophyllinae, Phyllostominae, and Stenodermatinae. In Yarina, 17 species were detected, while at XX de Enero, only 7 were detected (Table 1). This difference it possibly due to the lower sampling effort carried out in the last locality. The most captured species has been *Sturnira lilium*, which makes up 28% of the captured bats, followed by *Carollia perspicillata*. Of the other species, only single individuals have been captured.

Of the 40 females captured, 17 were evidently lactating (42%) and presented nipples highlighting an active reproductive status. This is particularly

evident for *Sturnira lilium* captured in Yarina, highlighting the presence of a reproductive site in the immediate vicinity of the place of capture.

Most of the species caught have a frugivorous diet (Table 1), while four have an insectivorous diet (gleaning animalivore) and two nectar-based (*Glossophaga soricina, Lonchophylla thomasi*).

DISCUSSION

The relatively brief duration of the survey allowed us only a preliminary assessment of the bats of the area, and the list compiled is very incomplete. The 19 species detected correspond to 27% of the species known in the Marañón, Ucayali area (Klingbeil & Willig, 2010; Díaz, 2011; Mori et al., 2012; Linares-Palomino et al., 2013; Fernández-Arellano & Torres-Vásquez 2013) and 29% of the species detected in similar habitats near Iquitos (Hice et al., 2004).

In general, the composition of the bat community detected during this short survey in PSNR corresponds to the typical composition of neotropical rainforests, where *Carollia perspicillata*, *Carollia brevicauda*, and *Sturnira lilium* are the most abundant species (Hice et al., 2004). In particular, *C. perspicillata* is the most captured bat along Río Ucayali (Mori et al., 2012).

Species richness and the abundance of frugivorous and insectivorous bats were clearly in favour of the former. The low abundance of insectivores could be attributed partially to a sampling bias, as some insectivorous species are particularly difficult to capture in mist nets because of their characteristic high and fast flight or their ability to avoid mist nets (Hice et al., 2004). This fact, together with flight behaviour at a high altitude, could also explain the almost total absence of captures of individuals of the families Vespertilionidae and in particular Molossi-

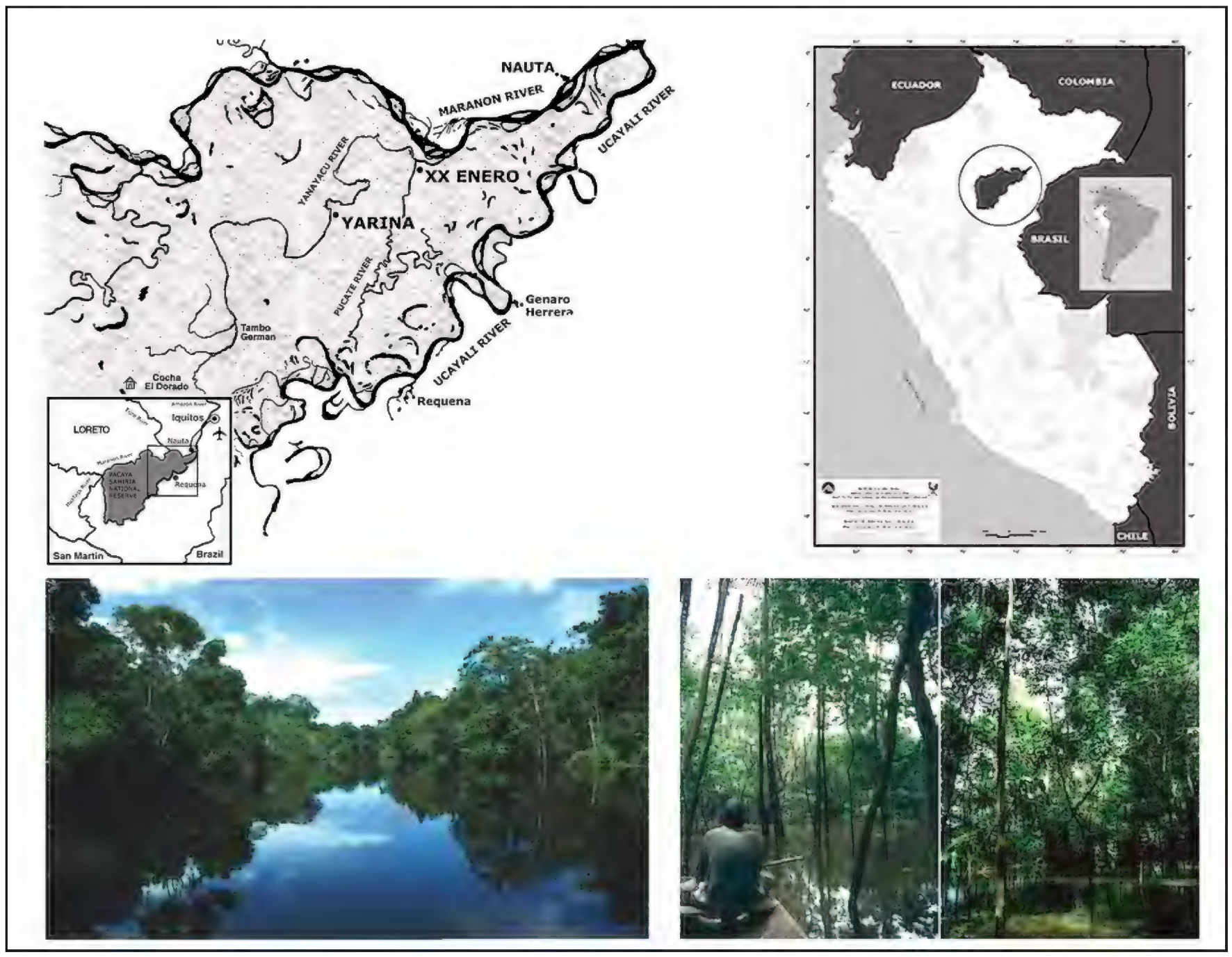

Figure 1. Map of the Rio Yanayacu-Pucate with the localization of Yarina and XX de Enero and view of the Rio Yanayacu-Pucate and flooded varzea forest close to XX de Enero.

Species	XX de Enero			Yarina			Guild
	Male	Female	**Total**	Male	Female	**Total**	
Emballonuridae - Emballonurinae							
Rhynchonycteris naso				1	1	**2**	GA
Phyllostomidae – Phyllostominae							
Phyllostomus elongatus				1	1	**2**	GA
Tonatia saurophila					1	**1**	GA
Trachops cirrhosus					1	**1**	GA
Phyllostomidae – Glossophaginae							
Glossophaga soricina					1	**1**	N
Phyllostomidae – Lonchophyllinae							
Lonchophylla thomasi				2		**2**	N
Phyllostomidae – Carolliinae							
Carollia brevicauda	1		**1**	1	1	**2**	F
Carollia castanea				3	1	**4**	F
Carollia perspicillata		3	**3**	1	5	**6**	F
Phyllostomidae – Stenodermatinae							
Artibeus anderseni	1		**1**				F
Artibeus obscurus	1		**1**	4		**4**	F
Artibeus planirostris	1		**1**	2	3	**5**	F
Dermanura glauca				1		**1**	F
Mesophylla macconnelli				2	1	**3**	F
Platyrrhinus brachycephalus	1		**1**	1	3	**4**	F
Sturnira lilium				6	15	**21**	F
Sturnira tildae				4	1	**5**	F
Uroderma bilobatum		1	**1**				F
Uroderma magnirostrum					1	**1**	F
Specimens collected			**9**			**65**	
Species			**7**			**17**	

Table 1. List of sampled bats by sex and diet guild: F frugivore, GA gleaning animalivore, N nectarivore.

dae. The ratio of the captures of the different guilds corresponds to their detectability by catching with mist nets on the ground (Meyer et al., 2011).

The number of lactating females corresponds to that observed in other areas of neotropical rainforests (Hice et al., 2004), and a similar pattern is commonly observed in neotropical phyllostomid frugivorous bats (Willig, 1985a; 1985b).

Despite the short duration of the survey and the lack of other sampling techniques that could have increased species richness (e.g., canopy nets, acoustic sampling, etc.) as indicated by Meyer et al. (2011), the collected data contribute to the knowledge of bats in PSNR and in the area between the Marañón, Ucayali, and Amazon rivers south of Iquitos. These, integrated with the bibliographic information available (Klingbeil & Willig, 2010; Díaz, 2011; Mori et al., 2012; Fernández-Arellano & Torres-Vásquez 2013; Linares-Palomino et al., 2013) within a buffer of 100 km from the sampled sites, provide a checklist of 72 species of bats (Table 2). Although the species detected during this brief survey are already known in the bibliography for the area, the data collected in this survey added a species, not previously reported (*Rhynchonycteris naso*), to the checklist of the buffer area. The presence of this species has recently been confirmed in the buffer area by an observation in February 2016 (https://www.inaturalist.org/observations/3350987).

Finally, more detailed investigations are still desirable using different sampling techniques (Meyer et al., 2011) to better define the status of data deficient species (e.g. *Peropteryx pallidoptera, Carollia benkeithi, Myotis simus*), but above all to better define the biodiversity of bats in the area, considering the recent description of new bat species in Loreto Departement (Simmons et al., 2002).

species	**IUCN**
EMBALLONURIDAE - EMBALLONURINAE	
Cormura brevirostris (Wagner, 1843)	LC
Diclidurus albus (Wied-Neuwied, 1820)	LC
Peropteryx macrotis (Wagner, 1843)	LC
Peropteryx pallidoptera Lim, Engstrom, Reid, Simmons, Voss et Fleck, 2010	DD
Rhynchonycteris naso (Wied-Neuwied, 1820)	LC
Saccopteryx leptura (Schreber, 1774)	LC
PHYLLOSTOMIDAE - MICRONYCTERINAE	
Micronycteris matses (Simmons, Voss et Fleck, 2002)	DD
Micronycteris megalotis (Gray, 1842)	LC
Micronycteris minuta (Gervais, 1856)	LC
PHYLLOSTOMIDAE - DESMODONTINAE	
Desmodus rotundus (É. Geoffroy, 1810)	LC
PHYLLOSTOMIDAE - PHYLLOSTOMINAE	
Chrotopterus auritus (Peters, 1856)	LC
Lophostoma brasiliense Peters, 1866	LC
Lophostoma carrikeri (Allen, 1910)	LC
Lophostoma silvicolum D'Orbigny, 1836	LC
Mimon crenulatum (É. Geoffroy, 1803)	LC
Phylloderma stenops (Peters, 1856)	LC
Phyllostomus elongatus (É. Geoffroy, 1810)	LC
Phyllostomus hastatus (Pallas, 1767)	LC
Tonatia saurophila Koopman et Williams, 1951	LC
Trachops cirrhosus (Spix, 1823)	LC
Vampyrum spectrum (Linnaeus, 1758)	LC
PHYLLOSTOMIDAE - GLOSSOPHAGINAE	
Anoura caudifer (É. Geoffroy, 1818)	LC
Choeroniscus minor (Peters, 1868)	LC
Glossophaga soricina (Pallas, 1766)	LC
PHYLLOSTOMIDAE - LONCHOPHYLLINAE	
Lionycteris spurrelli Thomas, 1913	LC
Lonchophylla thomasi J.A. Allen, 1904	LC
PHYLLOSTOMIDAE - CAROLLIINAE	
Carollia benkeithi Solari et Baker, 2006	DD
Carollia brevicauda (Schinz, 1821)	LC
Carollia castanea (H. Allen, 1890)	LC
Carollia perspicillata (Linnaeus, 1758)	LC
PHYLLOSTOMIDAE - "GLYPHONYCTERINAE"	
Glyphonycteris daviesi (Hill, 1964)	LC
Glyphonycteris sylvestris Thomas, 1896	LC
Trinycteris nicefori (Sanborn, 1949)	LC
PHYLLOSTOMIDAE - "RHINOPHYLLINAE"	
Rhinophylla fischerae Carter, 1966	LC
Rhinophylla pumilio Peters, 1865	LC
PHYLLOSTOMIDAE - STENODERMATINAE	
Artibeus anderseni (Osgood, 1916)	LC
Artibeus bogotensis K. Andersen, 1906	NE
Artibeus cinereus (Gervais, 1856)	LC
Artibeus concolor Peters, 1865	LC
Artibeus gnomus (Handley, 1987)	LC
Artibeus lituratus (Olfers, 1818)	LC
Artibeus obscurus (Schinz, 1821)	LC
Artibeus planirostris (Spix, 1823)	LC
Artibeus watsoni (Thomas, 1901)	LC
Chiroderma trinitatum Goodwin, 1958	LC
Chiroderma villosum Peters, 1860	LC
Dermanura glaucus (Thomas, 1893)	LC
Dermanura gnomus (Handley, 1987)	LC
Mesophylla macconelli Thomas, 1901	LC
Platyrrhinus brachycephalus (Rouk et Carter, 1972)	LC
Platyrrhinus helleri (Peters, 1866)	LC
Platyrrhinus infuscus (Peters, 1880)	LC
Sturnira lilium (É. Geoffroy, 1810)	LC
Sturnira magna de la Torre, 1966	LC
Sturnira tildae de la Torre, 1959	LC
Uroderma bilobatum Peters, 1866	LC
Uroderma magnirostrum Davis, 1968	LC
Vampyressa bidens (Dobson, 1878)	LC
Vampyressa brocki (Peterson, 1968)	LC
Vampyressa thyone Thomas 1909	LC
Vampyriscus bidens (Dobson, 1878)	LC
Vampyrodes caraccioli (Thomas, 1889)	LC
NOCTILIONIDAE	
Noctilio albiventris Desmarest, 1818	LC
MOLOSSIDAE - MOLOSSINAE	
Cynomops planirostris (Peters, 1866)	LC
Eumops maurus (Thomas, 1901)	DD
Molossus coibensis Allen, 1904	DD
Molossus molossus (Pallas, 1766)	LC
Molossus rufus E. Geoffroy, 1805	LC
VESPERTILIONIDAE - MYOTINAE	
Myotis nigricans (Schinz, 1821)	LC
Myotis riparius Handley, 1960	LC
Myotis simus Thomas, 1901	DD
THYROPTERIDAE	
Thyroptera lavali (Pine, 1993)	DD

Table 2. Checklist of the bats of the Marañón, Ucayali, and Amazon rivers south of Iquitos and their IUCN status: LC = Least Concern, NE = Not Evaluated, DD = Data Deficient.

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Observation on distribution, biology, growth, diet and feeding strategy of blackmouth catshark *Galeus melastomus* (Rafinesque, 1810) (Chondrichthyes Scyliorhinidae) in Western Algerian coast

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ABSTRACT

The blackmouth catshark *Galeus melastomus* (Rafinesque, 1810) (Chondrichthyes Scyliorhinidae) is an accidentally caught species and it acts as a sentinel, by reflecting the state of the region's fish stocks. Its vulnerability to the impact of fishing, along with the low fertility and late reproduction, do not ensure a good renewal. Data, collected during 13 months from November 2015 to November 2016, were analysed to enrich our knowledge on the population, reproductive biology, growth, and feeding strategy of the blackmouth catshark from the Western coast of Algeria. A total of 551 specimens, 360 males and 191 females, were caught. Their size ranged from 25 cm to 56 cm for both sexes. The length of the first sexual maturity was stunted at 54 cm in females. The asymptotic length was deduced from the von Bertalanffy growth equation to be higher for males than females (females: $L\infty = 51.79$ cm; males $L\infty = 52.14$ cm) and the study of the height-weight relationship revealed allometric growth. 551 stomachs were examined and the vacuity index was found to be 63.75%. The preys identified belonged primarily to three major groups: Crustaceans, Osteichthyes, and Cephalopods. Our results show that the feeding strategy of *G. melastomus* is to be considered generalist and differs from one month to another.

KEY WORDS

Galeus melastomus; Western Algerian coast; reproductive biology; growth; feeding.

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INTRODUCTION

The Blackmouth catshark, *Galeus melastomus* (Rafinesque, 1810) (Chondrichthyes Scyliorhinidae) is a small Elasmobranch distributed in the eastern Atlantic Ocean, from Norway to Senegal, and in the whole Mediterranean Sea (Compagno, 1984). Although its bathymetrical distribution is quite wide and ranges from 55 to 1,750 m of depth (Stefanescu et al., 1992; Relini et al., 1999), *G. melastomus* prefers muddy bottoms from 200 to 500 m in depth (Fisher et al., 1987; Compagno, 1984). In the western basin, it lives between 400 and 1,400 m in depth (Moranta et al., 1998). *Galeus melastomus* has a strong distribution, due to its morphological characteristics and quick adaptation to the environment, and is very abundant and frequent in the west coast of Algeria (Hemida, 2005). In the Mediterranean Sea the distribution, behaviour and biology of *G. melastomus* have been studied, mainly in the central area including Tunisia (Capapé & Zaouali, 1976, 1977), Italy (Relini Orsi &

Wurtz, 1975, 1977; Tursi et al., 1993; Sartor & Ranieri 1995; Scacco et al., 2002), and the western basin (Macpherson, 1980; Carrasón et al., 1992; Bozzano et al., 2001). These small sharks are considered a sentinel species and excellent indicators to reflect the state of the fish stocks of the ecosystem of which they are part, but the vulnerability to the impact of fishing, low fertility and late reproduction do not ensure a good renewal of the species (Camhi et al., 1998). The purpose of this document was to study the biological characteristics of *G. melastomus*, including the state of fecundity and maturity as well as the sex ratio and feeding habits, which are important parameters for the study of the dynamics of the reproduction of the populations of Elasmobranchs to evaluate the level of exploitation of the Algerian west coast.

MATERIAL AND METHODS

Study area

The hydrodynamic environment of the northern African coast is mainly conditioned by the strong influence of water interchange through the Strait of Gibraltar, a shallow and narrow channel 320 m deep and 14 km wide that connects the Mediterranean to the Atlantic Ocean. This strait allows low-density Atlantic waters to intrude into the Mediterranean as surface waters, while denser Mediterranean waters (high salinity waters resulting from low freshwater supply and high evaporation) travel at mid-depths into the Atlantic Ocean. The inflow of Atlantic water spreads along the Algerian coast, resulting in a general, anti-clockwise flow that forms the Almeria-Bouzedjar front, an anti-cyclonic gyre that joins the Iberian Peninsula to Algeria, and which also has small cyclonic gyres linked to it (Millot, 1999). The Atlantic waters flow into the Algerian sub-basin as the "Algerian current", a relatively narrow and deep current, 30–50 km wide and 200–400 m deep at the coast, which becomes thinner (in depth) and wider (in horizontal extension) in an easterly direction (Benzohra & Millot, 1995). The instability of this current leads to the development of a series of coastal eddies, associated with a non-wind-induced upwelling. The Mediterranean deep waters also flow along the Algerian continental slope with a general anticlockwise circulation, and it is hypothesized that they induce intense currents in the whole deep layer and near the bottom (Millot et al., 1997) (Fig. 1).

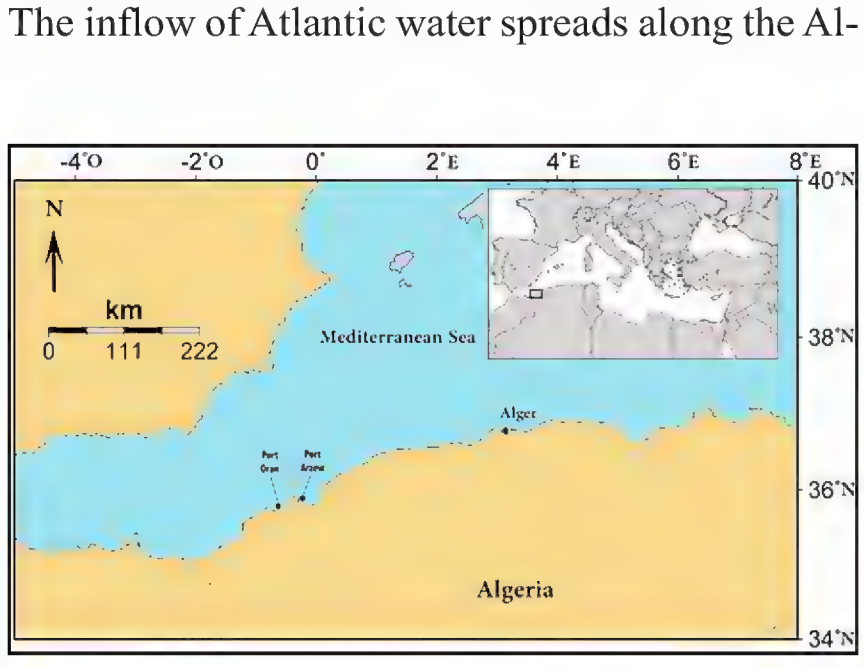

Figure 1. Location of the study area (Western Algerian coast).

Study of reproduction

A series of biological samples were conducted on specimens of *G. melastomus* caught by the commercial trawlers in the sampling area of Oran and Arzew (Fig. 1) during the period from November 2015 to November 2016. Specimens were measured and weighted; sex and maturity were reported for the females that represent the object of our study. Three different stages of maturity have been defined, according to Mellinger (1989), Rodriguez-Cabello et al. (2007) and Capapé et al. (2008) (Table 1).

In reference to the work of Cabello-Rodriguez (2008) and Capapé et al. (2008), to specify the spawning period, we used the oviduco-somatic index (*OSI*) which is the seasonal evolution of the weight of the capsules (*CW*) compared to the total weight of the individual (*TW*) expressed as a percentage, defined by the relation:

$$OSI = (CW/TW)*100$$

To follow the evolution of egg-laying, the hepato-somatic index (*HSI*) was calculated using the following equation:

$$HSI = (LW/TW)*100$$

where *LW* is the liver's weight and *TW* the total weight of the specimens. Variations in *OSI* and *HSI* related to sexual maturity stages were examined in

females, in order to know the morphological variations, the degree of overweight or fineness resulting from the genital development and the state of repletion of the target species.

Condition factor (*Kn*) (Le Cren, 1951) was studied in females in order to show differences related to time, according to the formula:

$Kn = W/Wth$ with $Wth = aLb$

where *W* is the total weight, *Wth* is the theoretical weight, *a* and *b* are the coefficients of the relative growth between weight and length and *L* is the total length.

The size of first sexual maturity was described by Fontana et al. (1969) as the size for which 50% of individuals are mature. This size is determined from the abscissa corresponding to the ordinate 50% (*L50*) of the logistic curve linking the percentage of mature females at size classes (Nelder 1961; Cardenas et al., 1997) corresponding to the expression:

$$pi = exp\ (a+b * Li)/\ 1+ exp\ (a+b * Li)$$

where *pi* is the proportion of the mature females, *a* and *b* are the coefficients of the equation and *Li* is the total length.

The sex-ratio analysis was performed by studying the global sex-ratio, sex-ratio by length classes and sex-ratio by seasons using the STATISTICA Software logistic model (StatSoft Inc, 2001) and calculating the χ^2 heterogeneity test with one degree of freedom, $p < 0.05$.

Growth study

The objective of this part of the study was to define several biological characteristics, such as the structure of the population size, and the growth and the age of *G. melastomus* in the study area.

There are several mathematical models to express the growth in Elasmobranchs. A detailed review was made by Beverton & Holt (1957), Ursin (1967), Gulland (1983), Sparre & Venema (1996), and Pauly & Moreau (1997). The most popular model is Von Bertalanffy growth equation:

$Lt = L\infty\ [1-]$

where *Lt* is the expected size at age *t* and $L\infty$ is the average maximum size.

In this study, the numerical method ELEFAN (Electronic Length Frequency Analysis; Pauly & Moreau, 1997) and the LFDA software (Kirkwood et al., 2001), for mathematical modeling, were used. Analyses were made for males and females, separately.

Study of diet and feeding strategy

This study, carried out during 13 months of sampling, allowed us to know the diet of *G. melastomus* in natural habitat, in addition to its feeding behavior and its trophic migrations, which could explain the influence that could exist on its reproduction (Stergiou & Kapouzi, 2002). This study also allowed to determine the different species that are a part of the same assemblage as the target species as well as the inter and intra specific relationships that can exist between them, for a better understanding of the structures and dynamics of marine stands (Silva, 1999).

Stomach sampling and analysis

551 stomachs were examined, of which 205 were full and 346 empty, the extracted stomachs were isolated, weighed and then placed in pill containers containing a 10% formalin solution, to (i) preserve stomachs samples while hardening the wall tissue of the stomachs and the prey's tissues to facilitate observation; and (ii) interrupt the activity of the gastric digestion performed by the stomach acids still present in the stomachs after landing (Olaso et al., 2005; Cabello-Rodriguez, 2008; Taleb Bendiab, 2014). Generally speaking, the analysis of stomach content is based on two analyses, a qualitative one which makes it possible to draw up a list as complete as possible of the preys ingested, and a quantitative one to stress the relative importance of the different preys found in the overall composition of the food and to highlight the possible variations of the diet (Quinius, 1978). The vacuity index (*Cv*) was calculated according to the formula proposed by Hureau (1970):

$Cv = Nev/N*100$

expressing the percentage of empty stomachs (*Nev*) relative to the total number of stomachs studied (N).

Three indices of prey classification were calculated to provide a representative interpretation of the diet of *G. melastomus*:

(1) index of relative importance (*IRI*) (Pinkas & al., 1971), $IRI = F + (Cn+Cp)$, where F = frequency of occurrence of the food item, Cn = percentage number of a prey species and Cp = percentage by weight of a prey species. According to the value of the *IRI*, preys are classified as follows: Main prey ($200 < IRI < 20{,}000$); Secondary prey ($20 < IRI < 200$); Accidental prey ($IRI < 20$).

(2) Food index (*IA*) of Lauzanne (1975), $IA = F*Cp/100$, where F = frequency of occurrence of the food item; Cp = percentage by weight of the food item: based on its values it is possible to distinguish: Secondary prey ($IA \leq 10$); Not negligible prey ($10 < IA \leq 25$); Essential prey ($25 < IA \leq 50$) and Dominant prey ($IA > 50$).

(3) The food coefficient (Q) (Hureau, 1970), $Q = Cn*Cp$, where Cn = percentage number of a prey species and Cp = percentage by weight of a prey species, According to the value of the Q, preys are classified as follows: Preferential ($Q > 200$); Accessory ($Q < 20$).

RESULTS

Reproductive aspects and maturity stage

In order to specify the spawning period and to follow its evolution, we used three biological indexes, the oviduco-somatic index (*OSI*) specific to Elasmobranchs, the hepato-somatic index (*HSI*) and the condition index (Kn). These indices allowed us to evaluate the morphological changes of the specimens and to determine the breeding season by studying the evolution stages of ovarian maturity.

The monthly results of the macroscopic observations of the gonads and the maturity stage of *G. melastomus* females are shown in figure 2. Following the calculation of the monthly averages of the *OSI* and *HSI* from 191 females, we drew up a graph illustrated in figure 3. The peaks observed correspond to the annual spawning period of the population. The highest values of *OSI* were found in December, March, April and May, while the lowest values in February, June, August, September and October. The highest values of the *HSI* occurred in December, April and May, the lowest in January, February, March, June and July (Fig. 3). The evolution of the condition factor (*Kn*) as a function of months on *G. melastomus* females over a period of 13 months is illustrated in figure 4. The values of *Kn* above 1 reveal a breeding period all along the annual cycle with the lowest values confirming a maturation period in December, March, and May.

Size at first maturity L50

The size at first maturity (L50) was estimated as 54 cm. We found substantially the same values in the Mediterranean, with differences in other regions of the world. All data are combined in Table 4.

Sex-ratio analysis

After sexing 551 specimens, we obtained a total femininity rate of 35.09% for a total masculinity rate of 64.90% (Table 2). According to the χ^2 significance test, we notice that males outnumber females. The length/abundance curve is shown in figure 5, and figure 6 shows the variation in percentage of males and females per month. The percentage of males is always dominant during all months.

Growth Parameters results

Table 4 includes the growth parameters $L\infty$ (asymptotic length), K (coefficient of growth), t0 the theoretical age at which the size is zero, and ϕ (growth index) calculated in this study. These values, once estimated for *G. melastomus* specimens, were then replaced in the equation of Von Bertalanffy; the parameters obtained from the equation did not differ significantly between the two sexes. We obtained a value of the asymptotic length $L\infty$, the growth coefficient K and the growth index ϕ, slightly different in favour of males (Table 5). The results of the height-weight relationship show a significantly lower allometry in both sexes, i.e., the weight does not grow faster than the cube of the length.

The adjusted values of a and b ($W = a\ Lb$) were used as input data in the stock assessment models. The biometric relations observed by analysis of relative growth are shown in Table 6. These results are close to the results obtained by other authors in different study areas (Table 7).

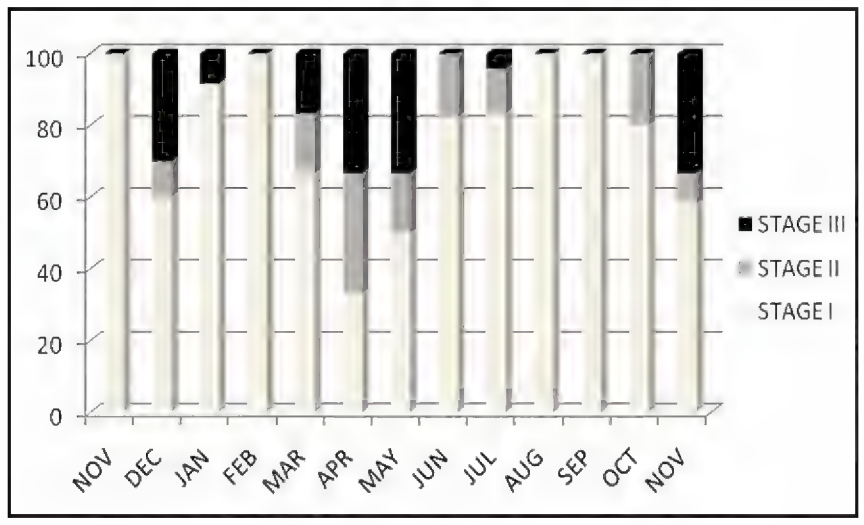

Figure 2. Percentages of different stages of sexual maturity in *Galeus melastomus* females per month.

Stage	Microscopic aspect (color and eggs' texture)
Immature (1)	No eggs and no Capsules
Beginning of maturation (2)	Ovaries small, light brown, egg-capsules rigid
Advanced maturation (3)	Ovaries enlarged, dark brown, egg-capsules rigid

Table 1. Different stages of maturity of *Galeus melastomus* females.

Sex	Total	Percentage
Females	191	34.66%
Males	360	*65.34%
Total	551	100

Table 2. Percentage of sexes in *Galeus melastomus* (*p<0.05).

Author	Areas	Males (cm)	Females (cm)
Tursi et al. (1993)	Ionian Sea (Mediterranean)	45	49
Moreno (1995)	Iberian waters, north-eastern Atlantic and Mediterranean	40	40
Costa et al. (2005)	Portuguese South coast	49	56-59
Rinelli et al. (2005)	Tyrrhenian Sea Mediterranean	44.30	48.80
Rey et al. (2005)	Alboran Sea Central Mediterranean	44	48.3
Capapé et al. (2008)	Languedocian coasts	51-55	52-61
Moore et al. (2012)	The Rockall Trough, north-east Atlantic	55.6	59.7
Christoforos et al. (2015)	Gulf of Euboca, Corinth, north western Aegea	44.7	49
Present study	Algeria (West)		54

Table 3. Comparison of size at first maturity by sex of *Galeus melastomus* for various geographical area.

Sex	Females	Males
Parameters	K L∞ to ϕ	K L∞ to ϕ
Results	0.42 51.79 -0.51 3.051	0.42 52.14 -0.93 3.057

Table 4. Growth parameters for *Galeus melastomus* females and males.

Sex	Von Bertalanffy Equation
Females	$L t = 51.79\ [1 - e^{-0.42(t+0.51)}]$
Males	$L t = 52.14\ [1 - e^{-0.42(t+0.93)}]$

Table 5. Von Bertalanffy Equation.

Sex	Wth= a L^b
Females	$W t h = 0.0085\ L^{2.809}$
Males	$W t h = 0.0035\ L^{2.909}$

Table 6. Biometric relation in *Galeus melastomus*.

Feeding intensity

After 13 months of sampling, from November 2015 to November 2016, with 346 empty stomachs and 205 full stomachs operated, we also determined ingested preys. For this period, the average *Cv* was 63.75%. Figure 7 represents the maximum values of the vacancy coefficient that were noted in August and October, summer and autumn, while the lowest values were recorded in May and December for males and females, respectively. This trophic activity could be related to the period of maturation and spawning. This nutritional need would provide sufficient energy for the development of the genitalia.

Diet composition (qualitative analysis)

The diet of *G. melastomus* in the waters of the western Algerian coasts was rather varied and mainly based on the undigested hard parts or whole

Sex	length (Cm)	a	b	r^2	Areas	Authors
M F	9.5-60 11.1-66.1	0.0025 0.0017	3.02 3.15		portuguese coast Mediterranean	Mendes et al. (2004)
M F	13.5-50 14-50	0.078 0.084	3.019 2.960	0.989 0.981	Tyrrhenian Sea Mediterranean	Rinelli et al. (2005)
M F	9-19	0.002 0.004	3.052 2.857		Aegean Sea Sigacik gulf Mediterranean	Özütemiz et al. (2007)
M F	34-64 32-69	0.038 0.0024	2.93 3.06		Rockall Trough Atlantic	Moore et al. (2012)
M F	25-55 29-56	0.0035 0.0085	2.909 2.809	0.934 0.938	Western algerian coasts	Present study

Table 7. Relation length weight of *Galeus melastomus* according to different authors.

phylum	class	subclass	superorder	order	family	genus	species
Crustacea	Malacostraca	Eumalacostraca	Eucarida	Decapoda	Pasiphaeidae	*Pasiphaea*	*sivado*
Arthropoda	Malacostraca	Eumalacostraca	Eucarida	Decapoda	Pasiphaeidae	*Pasiphaea*	*multidentata*
Arthropoda	Malacostraca	Eumalacostraca	Eucarida	Decapoda	Nephropidae	*Nephrops*	*norvegicus*
Arthropoda	Malacostraca	Eumalacostraca	Eucarida	Decapoda	Penaeidae	*Parapenaeus*	*longirostris*
Arthropoda	Malacostraca	Eumalacostraca	Eucarida	Decapoda	Sergestidae	*Sergestes*	*arcticus*
Arthropoda	Malacostraca	Eumalacostraca	Eucarida	Decapoda	Goneplacidae	*Goneplax*	*rhomboides*
Arthropoda	Malacostraca	Eumalacostraca	Eucarida	Decapoda	Goneplacidae	*Goneplax*	*nipponensis*
Mollusca	Cephalopoda	Coleoidea	Octopodiformes	Octopoda	Octopodidae	*Octopus*	*vulgaris*
Mollusca	Cephalopoda	Coleoidea	Decapodiformes	Myopsida	Loliginidae	*Loligo*	*vulgaris*
Chordata	Actinopterygii			Gadiformes	Gadidae	*Miscromesistius*	*poutassou*
Chordata	Actinopterygii			Perciformes	Carangidae	*Trachurus*	*trachurus*
Annelida	Polychaeta	Ind	Ind	Ind	Ind	Ind	Ind

Table 8. Diversity of prey ingested by *Galeus melastomus*.

Nature of prey	Total of prey	Cn	Cp	Q	LA	IRI
Crustaceans	491	112.0314	76.2238	717225.75	813.372	7358.5717
Cephalopoda	105	39.4743	39.9373	1225.3711	7.276	100.3025
Osteichthyes	89	19.4406	61.6301	1020.4408	9.272	106.0372
Undetermined	34	14.76	7.623	159.2625	0.274	26.5326

Table 9. Ranking of prey ingested by *Galeus melastomus* according to Hureau's methods (1970), Lauzanne (1975), and Pinkas et al. (1971).

organisms of three categories of preys: Crustaceans, Osteichthyes and Cephalopoda, of which 719 preys were counted (see Table 8). The determination of the different preys ingested by *G. melastomus* allowed us to calculate the different values of the dietary indices. Crustaceans are significantly present in both sexes with a value of 52.83%, then come the Cephalopoda with 24.25% and Osteichthyes with a value of 19.26% (Fig. 8).

Quantitative composition of the diet of Galeus melastomus

The calculated values of the different indices, Q, IRI, IA, show that Crustaceans are essential or preferential preys for males and females (Tables 9 and 10). Osteichthyes as well as Cephalopoda represent secondary preys, not insignificant. From the study of the different food indices we classified the different ingested preys as shown in Table 10.

DISCUSSION

From a sample collected during 13 months represented by a total workforce of 551 *G.melastomus* individuals sexed, the results show that the number of males was higher than the number of females, as already reported in the Mediterranean Sea, in the Alboran Sea, in the South Tyrrhenian Sea, in Gulf of Euboea and Corinth and North-Western Aegean off the Greek coasts and in Aegean Sea (Sığacık Gulf) (Rey et al., 2005; Rinelli et al., 2005; Özütemiz et al., 2007; Christoforos et al., 2015). We noted a fluctuation in the rate of masculinity with a significant dominance during autumn and winter, which could correspond to the maturation periods. We also observed a clear statistically significant decrease in the rate of masculinity tending to reach a numerical equality with females at the beginning of summer, i.e., in July, August and September, which could correspond to sexual rest or post-spawning periods. Regarding the correlation between sex and body size, one can observe that size classes between 25 and 55 cm of total length are almost significantly dominated by males, with only the two size classes 31 and 56 cm being dominated by females. This difference in size was also reported by other authors in the Mediterranean Sea, including in the south coast of Portugal (Costa et al., 2005), in the southern Tyrrhenian Sea (Rinelli et al., 2005), in the Alboran Sea (Rey et al., 2005) and in the Gulf of Euboea, Corinth, and North-Western Aegean (Christoforos et al., 2015), all pointing out the size difference between females and males, which could be explained by the fact that large females are likely to be less accessible to fishing gear as they move to specific reproduction areas (Rodriguez- Cabello et al., 1998). From the three indexes studied (OSI, HSI and Kn) we have determined the spawning period of the species. Moreover, from a macroscopic approach, we studied the sexual cycle of the species The breeding that appears to be annual with maximum phases of maturation occurs in December, April and May during the laying period, with interruptions occurring in February, August, September and October, which is the period of sexual rest or repletion of the target species. Many other authors (Capapé ,1977; Rey et al., 2005; Rinelli et al., 2005; Capapé et al., 2008) maintained that the reproduction would be annual, while we found periods of strong maturation of ovaries that differ from one fishery to another, probably influenced by variations in the environmental conditions and by fluctuations in bodies of water (Harris, 1952; D'Onghia et al., 1995).

To accurately determine breeding and spawning periods of species, either demersal or benthic, several indices are used. Referring to a work from ISRA-IRD (1979), it is recommended to use at least two indices when studying the reproduction of a target species. We note that the trend of the values of *OSI* and *HSI* is opposite to that of the condition factor (*Kn*). As for the latter studies, its values above 1 reflect an overweight, and therefore reveal a repro-

Method used	Ranking	Nature of prey
Hureau (1970)	preferential prey Q > 200	Crustaceans, Cephalopoda
	secondary prey 20 < Q < 200	
	accessory prey Q < 20	
Louzanne(1975)	IA > 50 dominant prey	Crustaceans
	25 < IA < 50 essential prey	
	10 < IA ≤ 25 not negligible prey	
	IA ≤ 10 secondary prey	Cephalopoda, Osteichthyes
Pinkas (1971)	200 < IRI < 20000 preferential prey	Crustaceans
	20 < IRI <200 accessory prey	Cephalopodes, Osteichthyes

Table 10. Classification of prey ingested by *Galeus melastomus* according to Hureau's methods (1970), Lauzanne (1975), and Pinkas et al. (1971).

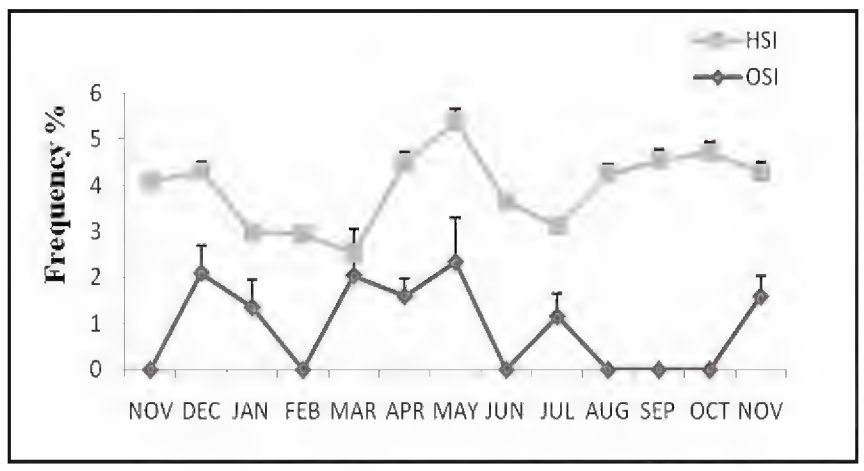

Figure 3. Monthly trend of OSI and HSI with standard errors in *Galeus melastomus* females.

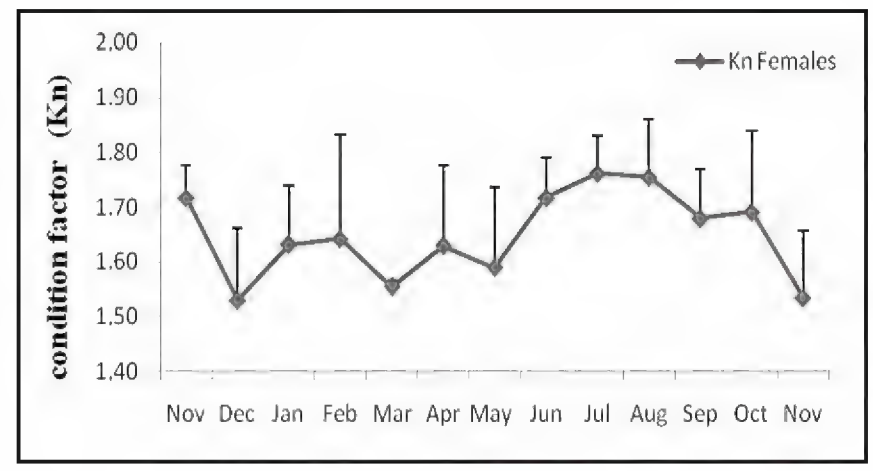

Figure 4. Condition factor (Kn) with standard error according to the season in *Galeus melastomus*.

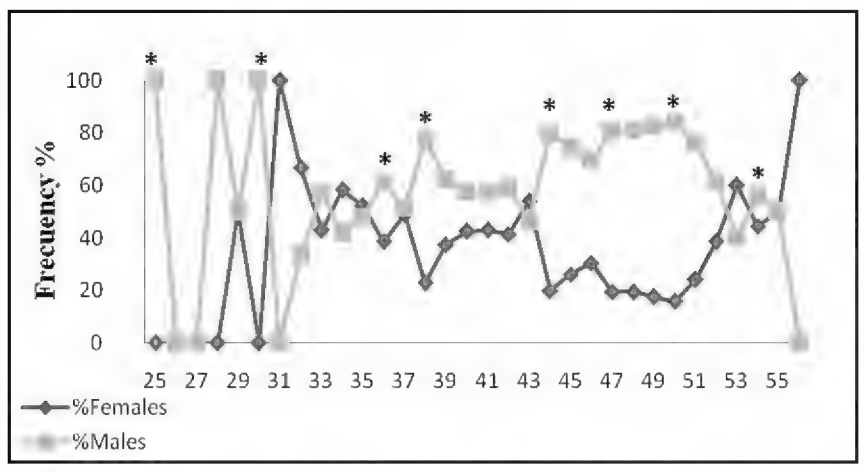

Figure 5. Abundance curve. Results of χ^2 test show a predominance of males over the females by length of specimens(* $p<0.05$).

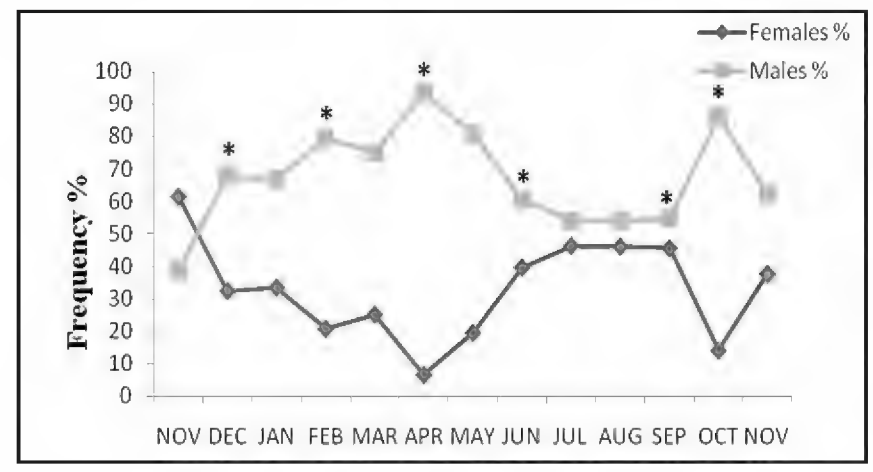

Figure 6. Distribution of males and females of *Galeus melastomus* by season. χ^2 test results show a prevalence of males over the females per sampling month.

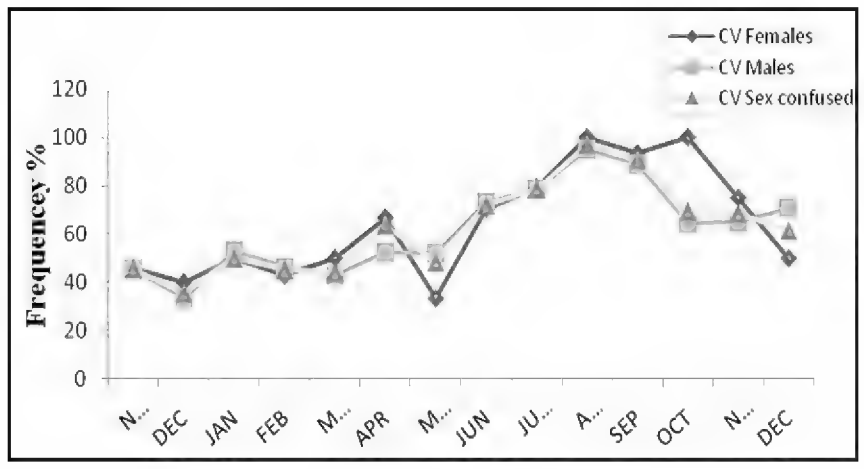

Figure 7. Variation of CV% according to sex in *Galeus melastomus*

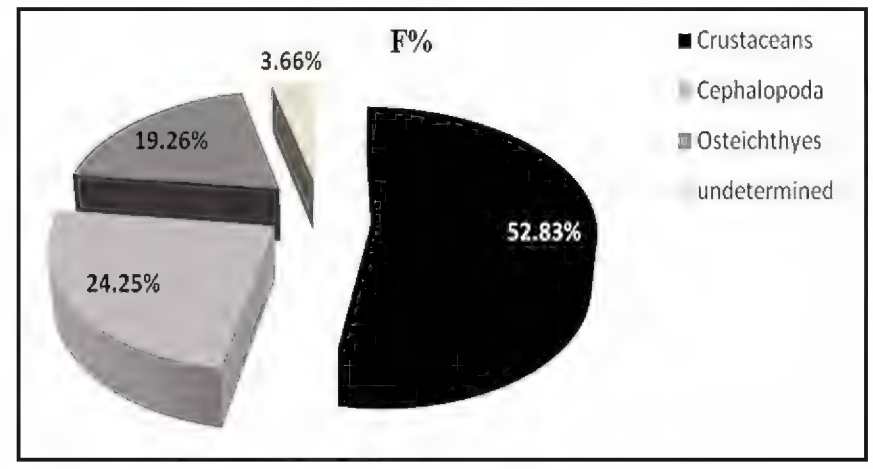

Figure 8. Variation of frequencies of prey ingested by *Galeus melastomus* (F%=Frequency of occurrence).

ductive period all along sampling and confirm a period of strong maturation in the intervals of December, March, April and May where the *Kn* values are relatively low. We estimated the size of first maturity (*L50*) at 54 cm, which is greater than that reported for the Mediterranean fisheries, as can be seen in Table 3. Tursi et al. (1993) also found that sexual maturity in *G. melastomus* would be reached around the third or fourth year of life and Capapé (1977) in Capapé & Brahim (1984) stated that maximum total length and size at first maturity are random in some species of selachians and, notably, that there could be very important variations within the Scyliorhinidae family. Notably, results obtained in our study confirm and support the results of the various authors mentioned above and the different

breeding parameters of *G. melastomus* differ from one region to another, under the influence of different environmental and geographical features (Leloup et al., 1951; Relini & Orsi-Relini, 1987; Demestre & Martín, 1993; Guijarro et al., 2007), such as the passage of Atlantic currents (rich in organic matter) entering the Mediterranean through the Gibraltar Strait, and the existence of many canyons providing enrichment of deep Algerian waters (Cartes et al., 2002).

The conclusions drawn from this work is that *G. melastomus* has a broad food spectrum, reflecting the richness of the environment in which it lives and the diversity of the assemblages of which it is a part of. This small shark feeds mainly on Crustaceans that represent its preference, whatever the age or sex, and on cephalopods and teleosts (mostly Gadidae) which represent secondary preys, in line with the conclusions of other authors regarding the importance of these three categories of preys in the diet of *G. melastomus* (Olaso et al., 2005; Neves et al., 2007; Fanelli et al., 2009; Anastasopoulou et al., 2013). The blackmouth catshark moves from the juvenile state to the adult state by changing its environment and the older it gets the more it moves to the coastal environments where the waters get less deep. This species has also been described as an active benthic eater using a wide range of active senses to find the preys (Olaso et al., 2005; Kimber et al., 2009). As previously reported (Olaso et al., 2005; Neves et al., 2007), *G. melastomus* food composition shows a certain heterogeneity of ingested preys - confirming that the species is both a generalist and an opportunistic - which means that the population occupies a large niche, where the individuals have much narrower niches. Taking into account the lack of reference works on this item, this study contributed to widen the knowledge of *G. melastomus* habits on the western Algerian coasts. Neverthless, further studies are certainly still needed to deepen our knowledge on this very important and fascinating species.

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Reproductive biology of *Diplodus vulgaris* (Geoffroy Saint-Hilaire, 1817) (Pisces Sparidae) in the western coast of Algeria

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ABSTRACT The study of the reproduction of *Diplodus vulgaris* (Geoffroy Saint-Hilaire, 1817) (Pisces Sparidae) of the Algerian West coast - carried out from September 2015 to August 2016 - related to 472 specimens, whose overall length ranged between 14.6 cm and 28.4 cm. The ratio of gonad weight to total weight was assessed monthly, and the evolution of the stages of sexual maturity revealed that, for *D. vulgaris*, the period of reproduction is between October and February with an oviposition in January. The sex ratio related to the size showed that males are dominant in the classes of small sizes (14–18 cm) and females dominate in the classes of great sizes (19–29 cm).

KEY WORDS *Diplodus vulgaris;* reproduction; Algeria; Western Mediterranean.

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INTRODUCTION

The common two-banded sea bream *Diplodus vulgaris* (Geoffroy Saint-Hilaire, 1817) (Pisces Sparidae) is a demersal species distributed in the Mediterranean and the Black Sea, along the French Atlantic up to Senegal (including the archipelago of the Madeira Islands, the Azores, and the Canaries), and even in Angola and in South Africa (Bauchot & Hureau, 1986, 1990). In this paper, we studied the sex ratio, the period of reproduction, the size of the first sexual maturity, as well as the process of differentiation of the gonads of *D. vulgaris* of the Algerian West coast.

Many authors have studied the reproduction of *D. vulgaris*, including Gonçalves & Erzini (2003), on the Southern coasts of Portugal; Lechekhab (2007), Nouacer et al. (2007) in the Golf of Annaba; Vienna & Adib (2007) in the Syrian coasts; and Hadj Taieb et al. (2012) in the Tunisian coasts.

However, to our knowledge, no study has been ever carried out in the western coast of Algeria.

MATERIAL AND METHODS

This study on the reproduction of *D. vulgaris* was carried out on a sample of 472 specimens between September 2015 and August 2016. The studied samples came from commercial unloading of goods in the port of Beni-Saf (Fig. 1).

Once at the laboratory, the samples were measured (in mm) and weighed (in mg). We determined the total weight (Wt), the weight of the gonads (Wg) and the weight of the liver (Wl). The fishes were dissected to determine the sex of each individual, as well as the various stages of sexual maturity.

The sex ratio indicates the rate of masculinity or of femininity in a batch. We calculated the rate of males (% male = number of males × 100/total num-

ber of males and females) and the rate of females (% females = number of females × 100/total number of males and females).

To describe the maturation stages of the gonads, and detect the period of reproduction, we assessed the gonadosomatic index (GSI), i.e. the calculation of the gonad mass as a proportion of the total body mass, which is a tool for measuring sexual maturity in correlation to ovary or testes development:

$$GSI = [Wg / Wt] \times 100$$

Moreover, in order to monitorate the physical conditions of the fish, two additional physiological indexes were considered: the first, the hepatosomatic index (HSI) (i.e. the ratio of liver weight to total body weight), allows to assess changes in liver weight during the reproductive cycle and is used as a measure of energy reserves and metabolic activity:

$$HSI = [Wl / Wt] \times 100$$

The second, the condition factor (or condition index) (Kn), reflects the changes in the general state of the fish according to the seasons, especially during the laying period. In fact, it is a way to measure the overall health of a fish by comparing its weight with the typical weight of other fish of the same kind and of the same length and is calculated dividing the actual weight (Wt) by the expected (theorical) weight (Wth):

$$Kn = [Wt / Wth] \quad \text{with } Wth = aLb$$

where L = total length of the fish (in cm); a and b = constants.

We also assessed the size of the first sexual maturity (Lt 50), i.e. the length for which 50% of the individuals are mature (Fontana, 1969). Finally, the calculation of the percentage of ripe fish gathered, starting from stage 2 of sexual maturity, was done by sex and size class of 1 cm. The determination of sex and the stages of sexual maturity of each sampled individual was based on the following morphological criteria: the color, the form and the vascularization of the gonads. In this study, we used the macroscopic scale of maturity of the gonads suggested by Mann & Buxton (1998), who reported and described four different stages:

Figure 1. Study area: the bay of Beni-Saf (Algeria).

Stage I: immature. Gonads are small. Thin and transparent testicles. Long and thin ovaries of translucent orange color;

Stage II: beginning of maturation (evolution of the gonads). The gonads increase in size. The testicles thicken and are white. The ovaries become inflated and of orange/yellow color. The eggs are visible to the naked eye;

Stage III: maturation and oviposition. The testicles are very large and inflated. They are white, but become often rosy as the season of reproduction progresses. Very large yellow ovaries. The translucent eggs are visible;

Stage IV: post oviposition. The testicles decrease in size and are of pink/gray color. The ovaries are injected with blood and of reduced size. The gonads can stay unchanged for several months.

RESULTS

After a sampling carried out on 472 specimens in 12 months and after having eliminated from the samples unidentified fishes, taking into account that hermaphrodites were classified as males or females according to the predominance of the gonads, females represented 54.82% and males 45.57%. Females are thus significantly ($p<0.05$) more numerous than males (Fig. 2) as confirmed also by the calculation of a statistical test of the χ^2 type. The sex ratio according to the size shows that males are dominant in the classes of small sizes (14–18 cm), while females dominate in the classes of great sizes (19–29 cm).

We noticed that the GSI values were higher in December and January, when they reached 1.67±0.23 and 1.87±0.36, respectively. The peaks observed correspond to the period of oviposition (Fig. 3). Then, it decreased gradually until April, during the period of sexual rest. The lowest values were observed during October (0.26±0.06) and September (0.18±0.04). The monthly follow-up of the HSI showed an annual peak (1.05) in January; the condition factor was stable throughtout the year with a slight increase in January as well (Fig. 3). The examination of the samples, according to the size, revealed that the population of *D. vulgaris* reached its first maturity (Lt 50) at 17.5 cm (Fig. 4).

The stages of maturity, according to Mann & Buxton (1998), are illustrated in figure 5. In females, the higher values for stage II and III were observed since October, with maximum values of stage III occurring in January. Most of the ovaries at stage IV were observed in March.

In males, stages II and III were observed since November, with maximum values of stage III during January. It was also observed that stage I was always present throughout the year with minimal values recorded from November to January in both sexes.

DISCUSSION AND CONCLUSION

The evolution of the stages of sexual maturity and the histological study of the gonads, as well as the gonadosomatic index, led to the same results thus confirming that the reproduction period of *D. vulgaris* starts in October and ends in February.

Our sampling consisted of 472 specimens, 246 females, 206 males, and 20 whose sex could not be determined. Of these, 14 hermaphrodites have been classified as males or females according to the predominance of the gonads and considered as such for the sex ratio which revealed, in general, an apparent predominance of the females compared to the males. Lechkhab & Djebar (2001) showed that, in *D. vulgaris*, males are met in the classes of small sizes while females are bigger. According to Warner & Hoffman (1980), this is explained by the fact that the males are younger and that early maturation blocks their somatic development.

GSI values observed in the present study are similar to those found by other authors in the Mediterranean (see Bauchot & Hureau, 1986; Riedl, 1986; Fischer et al., 1987; Cetinić et al., 2002; Zaki et al., 2004; Beltrano et al., 2003; Tsikliras et al., 2010).

The HSI evolves at the same time as the GSI, whereas the minimal values of the condition factor were observed during the month of February. Consequently, it seems that the changes in the HSI and Kn are associated to the sexual cycle. According to D'Ancona (1956), variations of these indexes make it possible to classify *D. vulgaris* among the so-called "oily fish" that is those fish whose liver is not involved in the process of accumulation of lipids.

Lechekhab (2007) too studied the evolution of the hepatosomatic index in *D. vulgaris* from Annaba Golf. He reported a slight increase of this index during the period of reproduction followed by a stabilization.

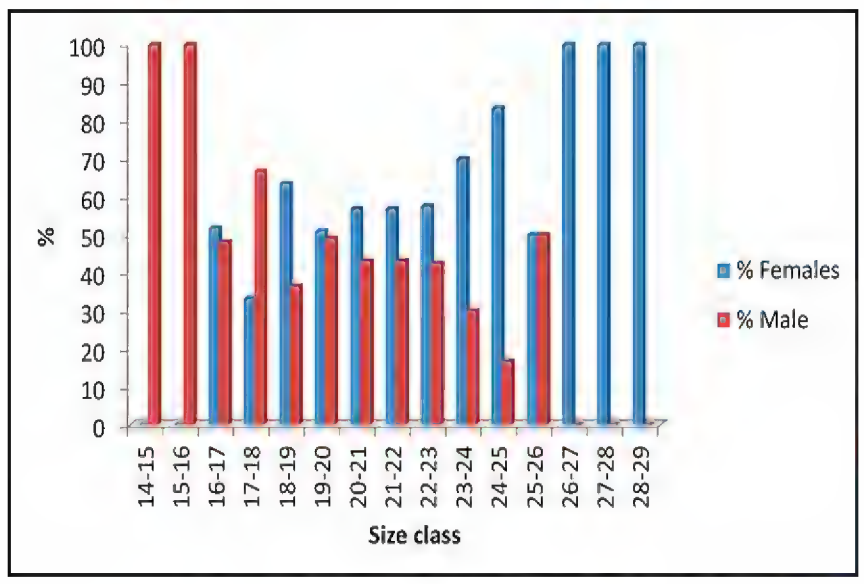

Figure 2. Monthly variation of sex-ratio by size classes for *Diplodus vulgaris* from the bay of Beni-Saf, western Algeria.

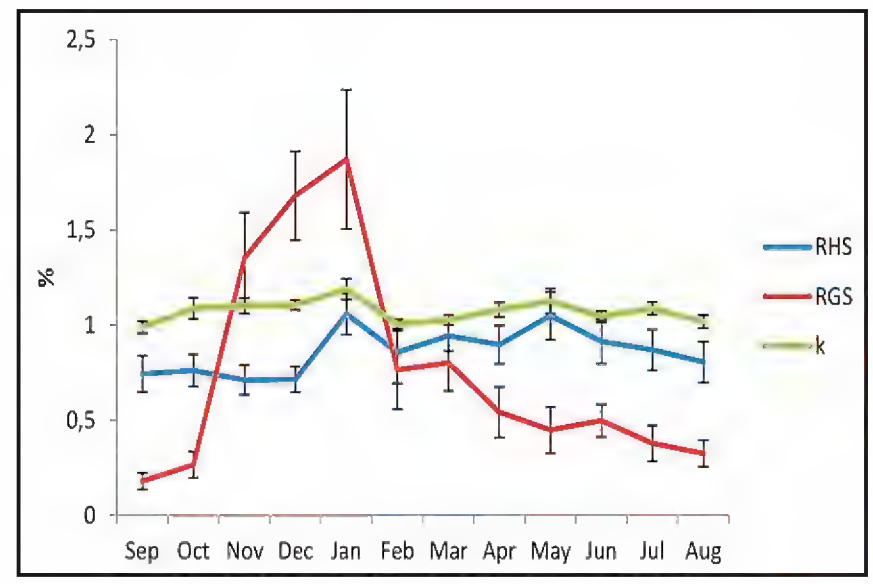

Figure 3. Monthly evolution of GSI, HSI and condition factor (Kn) for *Diplodus vulgaris* from the bay of Beni-Saf, western Algeria.

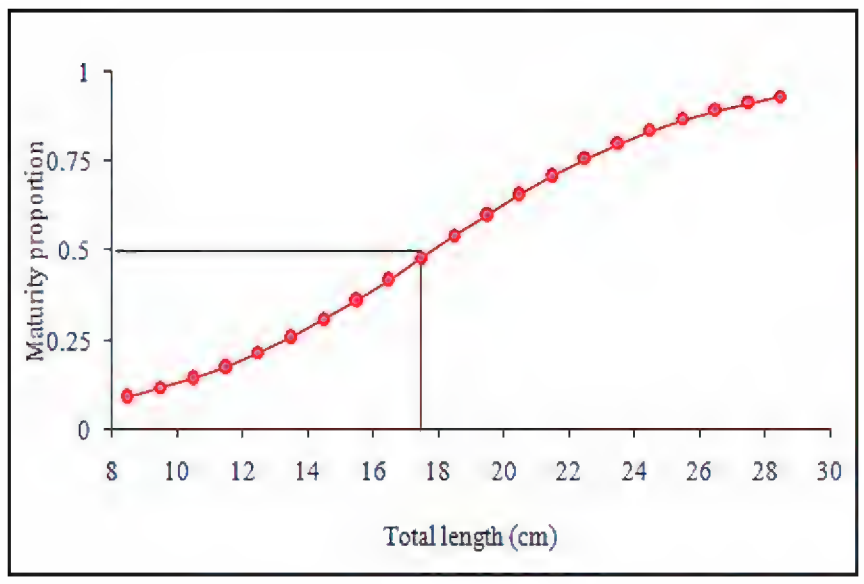

Figure 4. Logistic diagram of the relation between length and maturity for estimating the total length at 50% maturity.

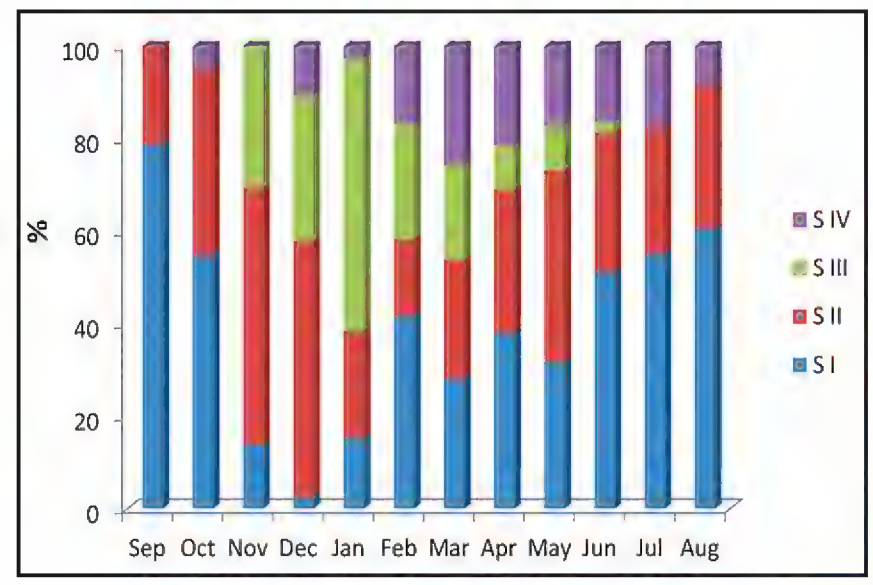

Figure 5. Monthly evolution of stages of sexual maturity for *Diplodus vulgaris* from the bay of Beni-Saf (Algeria).

According to our results, *D. vulgaris* reaches its first sexual maturity at 17.5 cm, matching those found by Gonçalves et al. (2003).

The macroscopic observation of the gonads of *D. vulgaris* confirms that this species has a reproduction period between October and February with a phase of oviposition in January.

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Phylogeographic relationships of Freshwater Crabs, *Potamonautes* Macleay, 1838, in Central Kenya in relation to similar species in Southern Africa highlands (Decapoda Potamonautidae)

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ABSTRACT

Fresh water crabs, *Potamonautes* Macleay, 1838 (Decapoda Potamonautidae) occurring in highland drainages in Africa are endemic to the specific region due to their geographically restricted habitats. Phylogenetic studies indicate that *Potamonautes* species in East, Central and Southern Africa regions have close genetic affinities and may be represented by the same genetic stock. In this study, fresh water crabs were sampled from the Aberdare ranges rivers in the Central highlands of Kenya to further characterize their phylogeny. Ribosomal DNA sequences derived from the samples and similar dataset of Eastern and Southern Africa regions were employed in phylogenetic analysis to determine populations' affinities. The constructed phylogenetic trees show that the molecular affinities are geographically structured where populations in Eastern and Western Rift Valley have closer genetic relationships, while Southern Africa populations are more distantly related. Further, time tree phylogenetics indicated that Eastern Africa *Potamonautes* are evolutionary older stocks relative to populations in Southern Africa. Tajima-D population drift neutrality test was negative, suggesting that the geographically isolated *Potamonautes* crabs populations are experiencing purifying selection.

KEY WORDS *Potamonautes*; Phylogenetics; Kenya; southern Africa.

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INTRODUCTION

Africa's freshwater crab, Decapoda Potamonautidae, is highly endemic at family, genus, and species levels and has restricted geographical distributions (Avise et al., 1987; Cumberlidge et al., 2009; Cumberlidge & Meyer, 2010). It is observed in East Africa, where each highland area supports endemic or restricted species (Dobson, 2004; Darwall et al., 2005). Three species belonging to the genus *Potamonautes* Macleay, 1838 are endemic to the Central Kenya highlands and are regionally separated between Mount Kenya and Aberdares ranges.

Information to clearly determine the conservation status of East Africa freshwater crabs is inadequate due to lack of data on clearly defined species, habitat locality and population densities. In the International Union for Conservation of Nature

(IUCN) red list categories and Criteria (IUCN, 2001; Cumberlidge et al., 2009), Kenyan highlands freshwater crabs have been highlighted as a population whose greater majority of species may be endangered or vulnerable, but with little information available to make a realistic assessment of their conservation status (Darwall et al., 2005). Since *Potamonautes* crabs are endemic with restricted range of distribution, they are potentially vulnerable to fragmentation of their habitats and agricultural land encroachment to the forests and this could result in their rapid decline in numbers.

Most species of *Potamonautes* are variously detritivorous or omnivourous, with feeding choices based on individual species size and locally available food. They feed on the fresh water aquatic vegetation and prey on small invertebrates and mollusks (Okafor, 1988; West et al., 1991; Dobson, 2004). The crabs occur in flowing rivers and are adapted to a wide range of habitats, though most species are restricted to high gradient streams or sluggish flowing regions of the rivers (Dobson et al., 2007a). Two or more species may co-exist in the same river, normally with one species occupying the river itself among the rocks while others occur in riparian marginal habitats in the trickles, the stream bank or even humid forests where some species are also semi-terrestrial (Cumberlidge, 1999; Darwall et al., 2005).

The current classification of the Central Kenya highlands freshwater crab is based on a recent revision of taxonomic keys (Cumberlidge et al., 2009) from a previous study by Bott (1955). This classification identified three species: *P. jeanneli* (Bouvier, 1921) and *P. odhneri* (Colosi, 1924) that originally were synonymous, while *P. alluaudi* (Bouvier, 1921) is recognized as a valid species rather than as a subspecies of *P. suprasulcatus* (Hilgendorf, 1898). Related classification studies (Peer et al., 2017) on freshwater crabs in mountain streams in Kwa-Zulu highlands (South Africa) using cytochrome oxidase I gene and 16S ribosomal genes re-defined *P. danielsi* Peer, Gouws, Lazo-Wasem, Perissinotto et Miranda, 2017 as a separate species from the clade of closely related *P. sidneyi* (Rathbun, 1904) (Gouws et al., 2015). These studies highlight difficulties in taxonomic separation of closely related individuals based on morphological characters and the relevance of augmenting classification using molecular analysis. In this study, we applied ribosomal DNA sequences to analyze phylogenetics of freshwater crabs from rivers draining the Aberdare ranges in Central Kenya and related the regional crabs to similar species in Eastern and Southern Africa geographical drainages (Daniels et al., 2015).

MATERIAL AND METHODS

Crabs sample collection

The crabs were sampled from various streams and tributaries draining the main central Kenyan highlands restricted to Muranga and Kiambu administrative boundaries. These streams border the highland farming lands and forested river line areas of the Aberdare ranges.

Sixty crab samples representative of each of the streams draining into the main rivers were collected from the streams and tributaries. The samples were stored alive and transported in containers with river water and specimens preserved at -20 °C until use.

DNA extraction

DNA was extracted from leg muscle tissue (Sambrook, 1987). The muscle tissue was incubated in 50 µg/ml proteinase K, 1 percent SDS in STE buffer (150 mM NaCl, 100 mM EDTA, 10 mM Tris–HCl, pH 7.4) at 55 °C for 3 h. The DNA was extracted from the lysate by the phenol:chloroform method and precipitated from the aqueous phase by adding 2–3 volumes of absolute ethanol. The pellet was suspended in 50–100 µl TE (10 mM Tris-HCl, 1 mM EDTA, pH 8.0). DNA concentration was measured by absorbance at 260/280 nm and the quality analyzed by electrophoresis in 1 percent agarose gel in 1× TAE buffer (40 mM Tris acetate, 1 mM EDTA, pH 8.0). Respective tubes with DNA were appropriately labelled and stored at -20 °C.

Polymerase chain reaction (PCR) and gene-clean procedures

In this study, 36 DNA samples representing fresh water crabs from Kenyan Central highlands were analyzed.

PCR was carried out using the following parameters: denaturation at 94 °C, 1 min annealing at 56 °C, 1 min and extension at 72 °C for 1 min 30 sec. The primers flanking region of 16S ribosomal RNA gene of *Potamonautes* species were applied. The

amplification products were verified on 1% agarose gel and the fragment excised from the gel, solubilized in sodium iodide solution then bound to (silica) column in the gene clean procedure. Bound DNA was eluted in 30 µl nuclease-free ddH_2O.

Sequencing

Gene cleaned DNA of the amplified fragments was sequenced at Macrogen Inc., Netherlands, using the Applied Biosystems Sanger's dye terminator method. Each of the analyzed samples was independently sequenced three times and the raw sequences with non ambiguous consensus selected. Representative consensus sequences were deposited in NCBI nucleotide database (GenBank Accession ID: KU847922–KU847957).

Phylogenetic and diversity analysis

Ribosomal DNA sequences derived from the present study were combined with related sequences obtained from NCBI's nucleotide database. Sequences were aligned using the Clustal-W program in BioEdit (Version 7.05) and the phylogenetic relationships inferred from the aligned nucleotide sequences by the Neighbour-Joining method at Boostrap 1000 replicates using Phylip program (Felsenstein, 1985) as implemented in the MEGA6 version suite (Tamura et al., 2013). In the analysis, multiple identical lineages were deleted to simplify data presentation. Analysis of number of haplotypes, allele diversity and population divergence was done in DNA sequence polymorphism statistics packages implemented in dnaSP V5 software (Librado & Rozas, 2009). Divergence time in the evolutionary history was inferred using Neighbour-Joining method (Saitou & Nei, 1987). The branching points in the tree topology were calculated with the RelTime method implemented in MEGA6 software. Haplotype network analysis was constructed using the Median-joining method in PopART program (Leigh & Bryant, 2015).

RESULTS

Potamonautes *phylogenetic clusters*

Ribosomal DNA gene sequence from samples across Eastern and Southern Africa showed few monophyletic lineages (Fig. 1: bold lines) that give rise to distinctive clusters of *Potamonautes* crabs by geographic regions. Sequences are derived from Kenyan highlands crabs representative clustered by watershed that drain to the Indian ocean and also to the closely related clusters representing crab populations in highland watershed that drain Western Lift Valley (Fig. 1: clusters in italic). The population of crabs in highlands watershed that drain to Lake Victoria and those in Lake Tanganyika showed different clusters (Fig. 1, bracket I). The crabs in the southern part of Lift Valley in Malawi are more closely related to species found in South Africa Drakensburg and Kwa-Zulu highlands (Fig. 1: bracket II, III).

Departure from Neutrality

Tajima-D test of population drift departure from neutrality showed that the Kenyan highland derived crabs had Tajima-D values comparable to those obtained by analyzing samples representing the larger Africa region south of equator (Table 1). When a population is at equilibrium neutrality, the nucleotide diversity (π) and the number of nucleotide segregating sites (Θ) are indistinguishable and the Tajima D value is near zero. The analysis of the two populations of *Potamonautes* crabs showed a weak negative Tajima's D test (-0.402999 and -0.415967) for Kenyan and Southern Africa populations, respectively.

Population divergence analysis of Kenyan derived crabs in relation to the rest of Southern Africa group showed a comparable number of haplotypes, but Kenyan population had relatively higher nucleotide diversity (Table 2). There were 65 shared mutations but no fixed difference in the samples analyzed.

Haplotype network

Haplotype network of evolutionary relationships among populations of *Potamonautes* from Eastern and Southern Africa was based on rDNA sequence applied in determining haplogroups. Fourty-seven haplotypes of Eastern and Southen Africa *Potamonautes* were analyzed using median-joining haplotype network (Fig. 2) implemented in popPART. The visualized genealogical relationships showed

similar clusters separation observed in phylogenetic tree where regional populations are separated though some haplotypes from Lake Malawi region appear to share genealogy with Kenya highlands derived samples.

Evolutionary time distance in Eastern and Southern Africa Potamonautes

Molecular time divergence analysis of the *Potamonautes* show that the Eastern African population represents and older genetic stock with early branching lines approximately 40 to 55 million years ago that further diverged 10 to 30 million years ago while the southern African stock is 1 to 5 million years ago, a comparatively recent time (Fig. 3). The Western Rift Valley and Lake Malawi stocks are phylogenetically closer to Southern Africa *Potamonautes* population (Fig. 3: in italic, brackets II and II).

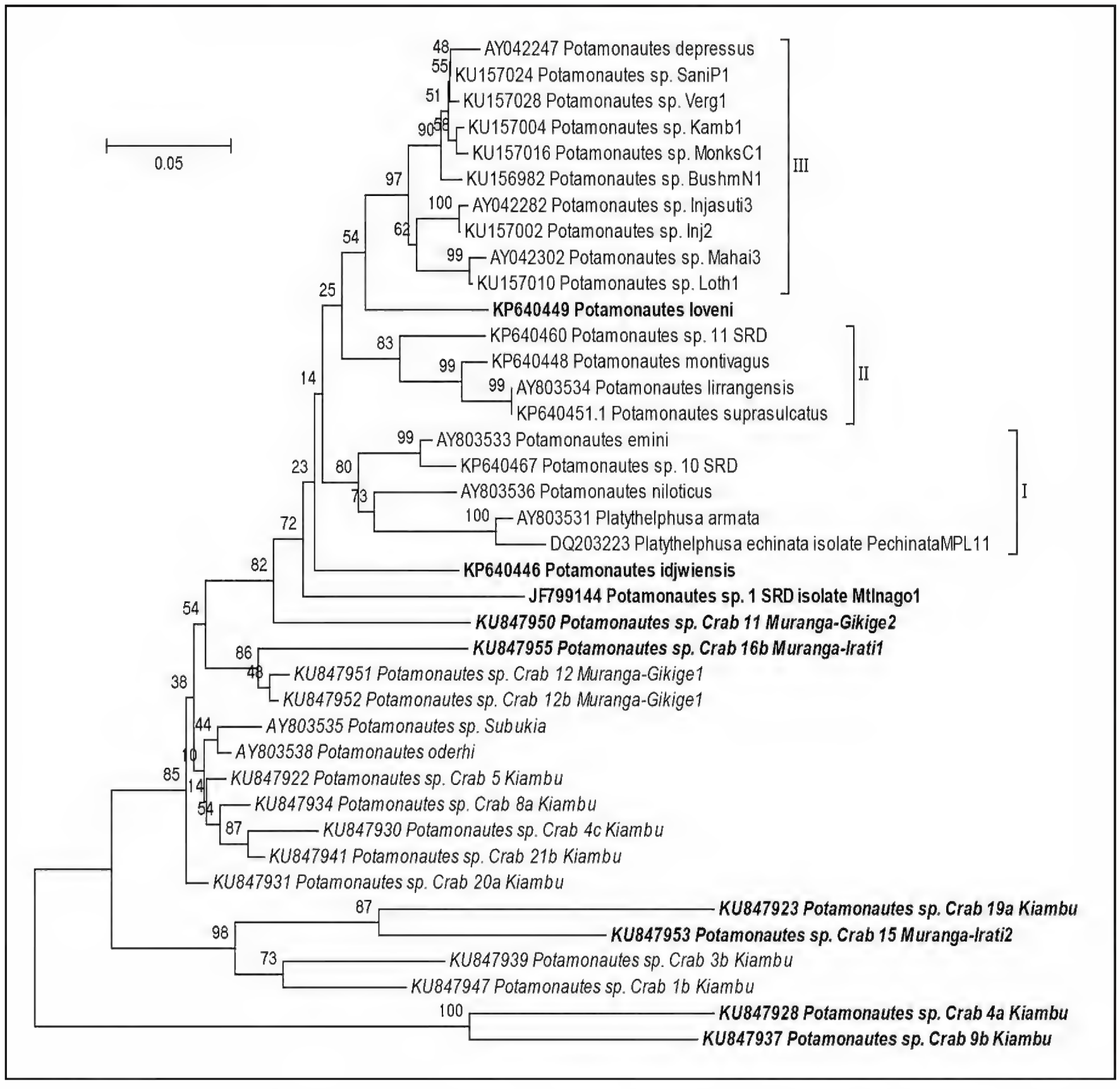
0.05
AY042247 Potamonautes depressus
KU157024 Potamonautes sp. SaniP1
KU157028 Potamonautes sp. Verg1
KU157004 Potamonautes sp. Kamb1
KU157016 Potamonautes sp. MonksC1
KU156982 Potamonautes sp. BushmN1
AY042282 Potamonautes sp. Injasuti3
KU157002 Potamonautes sp. Inj2
AY042302 Potamonautes sp. Mahai3
KU157010 Potamonautes sp. Loth1
III
KP640449 Potamonautes loveni
KP640460 Potamonautes sp. 11 SRD
KP640448 Potamonautes montivagus
AY803534 Potamonautes lirrangensis
KP640451.1 Potamonautes suprasulcatus
II
AY803533 Potamonautes emini
KP640467 Potamonautes sp. 10 SRD
AY803536 Potamonautes niloticus
AY803531 Platythelphusa armata
DQ203223 Platythelphusa echinata isolate PechinataMPL11
I
KP640446 Potamonautes idjwiensis
JF799144 Potamonautes sp. 1 SRD isolate MtInago1
KU847950 Potamonautes sp. Crab 11 Muranga-Gikige2
KU847955 Potamonautes sp. Crab 16b Muranga-Irati1
KU847951 Potamonautes sp. Crab 12 Muranga-Gikige1
KU847952 Potamonautes sp. Crab 12b Muranga-Gikige1
AY803535 Potamonautes sp. Subukia
AY803538 Potamonautes oderhi
KU847922 Potamonautes sp. Crab 5 Kiambu
KU847934 Potamonautes sp. Crab 8a Kiambu
KU847930 Potamonautes sp. Crab 4c Kiambu
KU847941 Potamonautes sp. Crab 21b Kiambu
KU847931 Potamonautes sp. Crab 20a Kiambu
KU847923 Potamonautes sp. Crab 19a Kiambu
KU847953 Potamonautes sp. Crab 15 Muranga-Irati2
KU847939 Potamonautes sp. Crab 3b Kiambu
KU847947 Potamonautes sp. Crab 1b Kiambu
KU847928 Potamonautes sp. Crab 4a Kiambu
KU847937 Potamonautes sp. Crab 9b Kiambu

Figure 1. Evolutionary relationships of *Potamonautes* crabs from Eastern and Southern Africa. The evolutionary history was inferred using the Neighbor-Joining method. The tree is drawn to scale, with branch lengths in the same units as those of the evolutionary distances and the percentage boostrap (1000 replicates) are shown at the branches. Kenya region derived crabs are in italic. Evolutionary analyses were conducted in MEGA6.

DISCUSSION

Africa's *Potamonautes* fresh water crabs are found throughout the non-arid areas of the continent with high diversity of the species occurring in forested areas of equatorial Africa and in lower diversity in savanna regions. The crabs are found in slow flowing rivers in over a wide range of habitats. Two or more species may co-exist in the same river, with one species occupying the river and others occurring in adjacent riparian environment, so the humid semi-terrestrial environments, can be as important to them as the aquatic environment (Bott, 1955; Cumberlidge, 1999; Cumberlidge et al., 2009).

The crabs are highly endemic at the family, genus, and species levels (Cumberlidge, 1999). In East Africa, each highland area supports endemic or restricted species within linked rivers and streams (Dobson, 2004), but there occurs admix-

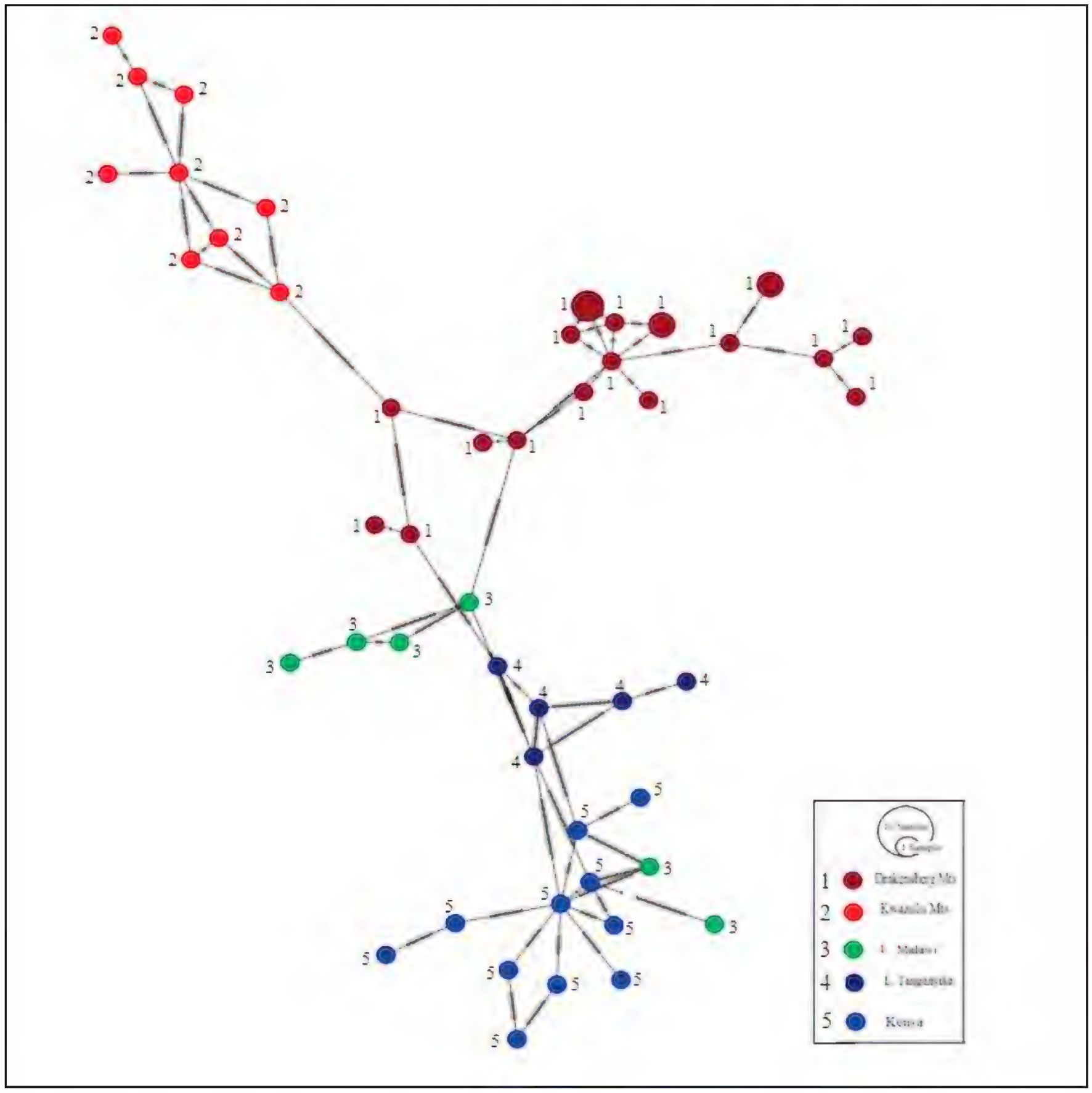

Figure 2. Network tree for Eastern and Southern Africa *Potamonautes* populations. The size of the circles correspond to numbers of individuals in different haplotypes indicated by colors. Divergence between haplotypes is illustrated by the number of hatch marks between haplotypes.

tures via translocation of these crabs within narrow geographic regions. Morphological examination of the type of crab specimens from Mt Kenya and Aberdares (Cumberlidge et al., 2009; Dobson et al., 2007a; 2007b) identified three species: *P. odhneri*, *P. jeanneli*, and *P. alluaudi*, in which *P. odhneri* was the most abundant. However, as the taxonomy of this group is poorly understood, there has been a re-description of the three species on basis of sizes and other morphological parameters. *Potamonautes alluaudi* adult size ranges at cross-section width from 44 to 55 mm, while *P. jeanneli* or *P. odhneri* adults are at cross-section width 22 and 32 mm respectively, but distinguishing juvenile sizes versus adult sizes is problematic.

The species of *Potamonautes* from Central Kenya highlands have not been defined at molecular level. In this study, ribosomal DNA sequences were applied for phylogenetic analyses (Saitou & Nei, 1987) of crabs collected in randomly selected rivers and streams draining the Aberdare ranges. The results show that these Kenyan specimens relate with *P. odhneri* (Figs. 1, 3) and the closely related to *Potamonautes* Subukia isolate previously described by Daniels et al. (2015). This is conceivable since rivers in Subukia region drain to Rift Valley, westwards from the Aberdare ranges. There are possibly four major clusters defined from the sequence data from Aberdare ranges isolates

Tajima's Neutrality Test						
	m	***S***	p_s	Θ	π	***D***
***Potamonautes* (Kenya)**	36	189	0.658537	0.158807	0.141806	-0.402999
***Potamonautes* (Southern Africa)**	81	194	0.769841	0.155039	0.136187	-0.415967

Table 1. *Potamomautes* from Kenya. The analysis involved 36 nucleotide sequences. There were a total of 287 positions in the final dataset *Potamonautes* from Southern Africa. The analysis involved 81 nucleotide sequences. There were a total of 252 positions in the final dataset. Abbreviations: *m* = number of sequences, *n* = total number of sites, *S* = number of segregating sites, *Ps* = S/n, Θ = Ps/a1, π = nucleotide diversity, and D is the Tajima test statistic (π and S/a1 both estimate Θ, where E (expected) E [π] = Θ, E [S] = a1Θ), software default significant at $P < 0.10$. Analyses were conducted in MEGA6.

Divergence between Populations	
Population 1: *Potamonautes* **(Kenya)** Number of sequences: 39	**Population 2:** *Potamonautes* **(Southern Africa)** Number of sequences: 42
Number of Haplotypes, h: 36	Number of Haplotypes, h: 37
Nucleotide diversity (per site), Pi: 0.14304	Nucleotide diversity (per site), Pi: 0.08732
Between populations: Mutations polymorphic in population 1, but monomorphic in population 2: 192 Mutations polymorphic in population 2, but monomorphic in population 1: 66 Shared Mutations: 65 Number of fixed differences: 0	

Table 2. Diversity differences and genetic divergence between *Potamonautes* in Kenya versus Southern Africa population conducted using DnaSP V5 software. (Significance: $P < 0.10$).

(Fig. 1: lineages in italic), each restricted to separate river drainages, suggesting that further revision of species in reference to *P. alluaudi*, commonly reported along Aberdare ranges, need to be done combining molecular data with morphological classification. Cross analysis with previously published sequences indicate that *P. suprasulcatus* belong to a distant clade found in southern Tanzania/Malawi highlands linked to the Western Rift Valley and geographically separated from Kenyan Central highlands. Phylogenetic analysis (Fig. 1) is indicative of monophyletic lineages that expanded to distinctive clusters in their respective highland drainages. Most freshwater organisms such as crabs and crayfish are isolated to specific aquatic inland systems with either restricted or no dispersal between drainages and can therefore be used to examine hydrological patterns over evolutionary time (Avise & Felley, 1979; Nicolas et al., 2011; Phiri & Daniels, 2013).

The highland fresh water crabs in Eastern and Southern Africa are phylogenetically distinct with endemic species in each of the separated highlands. Tajima-D test of genetic drift from population neutrality (Tajima, 1989; Nei & Kumar, 2000) show that these crabs inhabiting these highlands are at weak negative drift (-0.42 and -0.40) for Southern Africa region and Kenyan isolates, respectively (Table 1). This indicates few mutations that accumulate at silent sites but low average heterozygosity possibly as a result of being long time geographically isolated populations that are experiencing purifying selection over evolutionary time. Population divergence analysis of *Potamonautes* crabs sampled within Kenyan compared to Southern Africa population showed a comparable number of haplotypes, but Kenyan population had relatively higher nucleotide diversity (Table 2). The data showed 65 shared mutations, but no fixed difference in the samples analyzed. This may indicate a common ancestral stock that has been separated by geographic barriers over evolutionary time, but is experiencing comparable habitat conditions.

The high altitude *Potamonautes* in Africa are relatively small in size (Cumberlidge et al., 2009; Dobson et al., 2004; Daniels et al., 2006), that is sometimes interpreted as convergent adaptation to the habitat, but evidence of gene sequence phylogenetic relationship indicate a singular ancestral stock. For example, haplotype network analysis (Fig. 2) showed that *Potamonautes* stocks in Western Rift Valley and Southern Tanzania are presumably the geneological link between Kenya derived populations and those from Malawi and Southern Africa (Peer et al., 2017). Ribosomal DNA sequence data obtained in this study (Figs. 1, 3) for *Potamonautes* in central Kenya highlands, Tanzania highlands, Malawi and Southern Africa highlands show genetic distance separation coupled to geographic distance between them. While each regional highland clade is distinct, the genetic distance separation increases with geographic distance. The regional distinctive clusters are reflective of isolated aquatic populations with either restricted or no dispersal between drainages (Avise & Felley, 1979; Avise et al., 1998; Phiri & Daniels, 2013; Daniels & Klaus, 2018), providing evidence for phylogeographic drainage patterns across the continent of Africa. The estimated divergence times suggests that the Afrotropical Potamonautidae diverged during the Eocene to Oligocene period 25 to 55 million years ago (Daniels et al., 2015; Daniel & Klaus, 2018), that coincided with the geological formation of the Eastern Africa Rift Valley and re-direction of regional river drainages, while the Southern Africa highlands *Potamonautes* clades are relatively recent, arising in Miocene to Pleistocene period approximately 1 to 20 million years ago (Phiri & Daniels, 2013; 2014). The evolutionary time tree constructed using sequence data in this study (Fig. 3) demonstrates approximately a similar time divergence of *Potamonautes* clusters in Eastern Africa and Southern Africa highlands as observed in the previous studies.

The Kenyan samples in this study are from Aberdare ranges drainages to rivers leading to the Eastern coastline (Indian Ocean), while other rivers drain westwards to rift valley lakes. The previously described sample of the Subukia species (GenBank ID AY803535) (Daniels et al., 2015) is presumably from Central Kenya highlands draining westwards to the Lift Valley, hence the lineage affinities to crabs originating from these highlands (Fig. 1). The Lake Victoria catchment includes rivers from Western Kenya highlands and northern Tanzania have a distinctive *Potamonautes* species stock represented by *P. niloticus* and *P. emini*, while lake Tanganyika restricted drainage within the Western Rift Valley

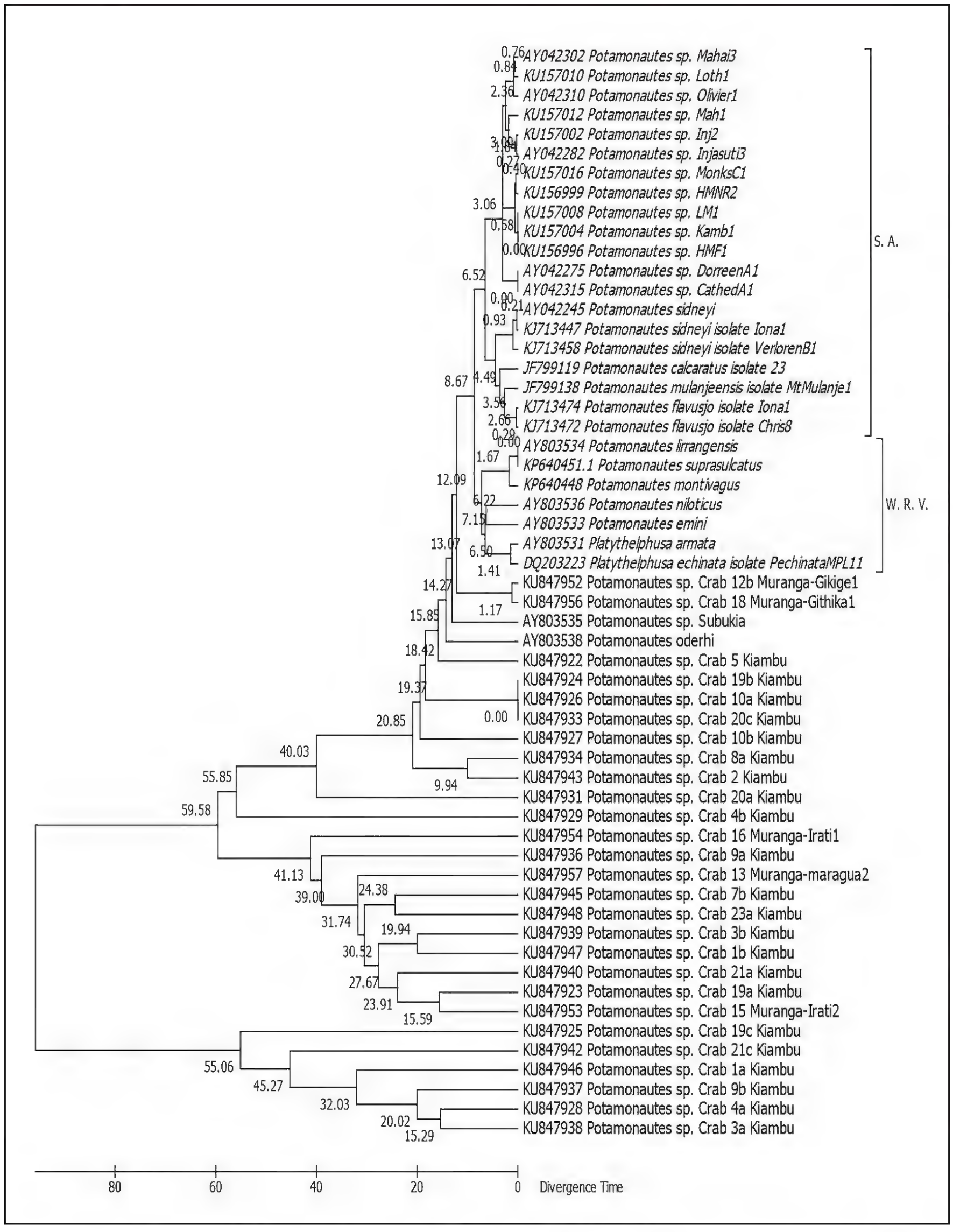
AY042302 Potamonautes sp. Mahai3
KU157010 Potamonautes sp. Loth1
AY042310 Potamonautes sp. Olivier1
KU157012 Potamonautes sp. Mah1
KU157002 Potamonautes sp. Inj2
AY042282 Potamonautes sp. Injasuti3
KU157016 Potamonautes sp. MonksC1
KU156999 Potamonautes sp. HMNR2
KU157008 Potamonautes sp. LM1
KU157004 Potamonautes sp. Kamb1
KU156996 Potamonautes sp. HMF1
AY042275 Potamonautes sp. DorreenA1
AY042315 Potamonautes sp. CathedA1
AY042245 Potamonautes sidneyi
KJ713447 Potamonautes sidneyi isolate Iona1
KJ713458 Potamonautes sidneyi isolate VerlorenB1
JF799119 Potamonautes calcaratus isolate 23
JF799138 Potamonautes mulanjeensis isolate MtMulanje1
KJ713474 Potamonautes flavusjo isolate Iona1
KJ713472 Potamonautes flavusjo isolate Chris8
AY803534 Potamonautes lirrangensis
KP640451.1 Potamonautes suprasulcatus
KP640448 Potamonautes montivagus
AY803536 Potamonautes niloticus
AY803533 Potamonautes emini
AY803531 Platythelphusa armata
DQ203223 Platythelphusa echinata isolate PechinataMPL11
KU847952 Potamonautes sp. Crab 12b Muranga-Gikige1
KU847956 Potamonautes sp. Crab 18 Muranga-Githika1
AY803535 Potamonautes sp. Subukia
AY803538 Potamonautes oderhi
KU847922 Potamonautes sp. Crab 5 Kiambu
KU847924 Potamonautes sp. Crab 19b Kiambu
KU847926 Potamonautes sp. Crab 10a Kiambu
KU847933 Potamonautes sp. Crab 20c Kiambu
KU847927 Potamonautes sp. Crab 10b Kiambu
KU847934 Potamonautes sp. Crab 8a Kiambu
KU847943 Potamonautes sp. Crab 2 Kiambu
KU847931 Potamonautes sp. Crab 20a Kiambu
KU847929 Potamonautes sp. Crab 4b Kiambu
KU847954 Potamonautes sp. Crab 16 Muranga-Irati1
KU847936 Potamonautes sp. Crab 9a Kiambu
KU847957 Potamonautes sp. Crab 13 Muranga-maragua2
KU847945 Potamonautes sp. Crab 7b Kiambu
KU847948 Potamonautes sp. Crab 23a Kiambu
KU847939 Potamonautes sp. Crab 3b Kiambu
KU847947 Potamonautes sp. Crab 1b Kiambu
KU847940 Potamonautes sp. Crab 21a Kiambu
KU847923 Potamonautes sp. Crab 19a Kiambu
KU847953 Potamonautes sp. Crab 15 Muranga-Irati2
KU847925 Potamonautes sp. Crab 19c Kiambu
KU847942 Potamonautes sp. Crab 21c Kiambu
KU847946 Potamonautes sp. Crab 1a Kiambu
KU847937 Potamonautes sp. Crab 9b Kiambu
KU847928 Potamonautes sp. Crab 4a Kiambu
KU847938 Potamonautes sp. Crab 3a Kiambu
S. A.
W. R. V.
80
60
40
20
0
Divergence Time

Figure 4. Evolutionary time tree relationships of *Potamonautes* from Eastern and Southern Africa. The evolutionary history was inferred using the Neighbor-Joining method. Divergence times for all branching points in the topology were calculated with the RelTime method using the branch lengths contained in the inferred tree. Relative times were optimized and converted to absolute divergence times (shown next to branching points). The analysis involved 56 nucleotide sequences. Evolutionary analyses were conducted in MEGA6. Abbreviations: S.A. (Southern Africa), W.R.V. (Western Rift Valley).

has distinctive endemic stock of *P. platynotus* and species on the genus *Platythelphusa* A. Milne-Edwards, 1887 (Cumberlidge et al., 1999; Marijnissen et al., 2004).

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The plant diversity and conservation status of the Taurus and Amanos mountains in the Eastern Mediterranean Region of Turkey

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ABSTRACT In this study, the Taurus and Amanos mountains of Turkey's eastern Mediterranean region offer an overview of the floristic features. A total of 1,259 vascular plant taxa belonging to 106 families and 469 genera were recorded from the research area as a result of various researches and field studies conducted between 1999–2017. The phytogeographic elements were represented in the study as follows: Mediterranean 328 (26.1%), Irano-Turanian 157 (12.5%), Euro-Siberian 87 (6.8%), cosmopolitan and unknown 687 (54.6%). The total number of endemic species was 195 and the endemism rate was 15.1%. According to the IUCN Red List Categories, 195 threatened plant species were found in the study area. As in all mountainous environments, climate, soil and vegetation characteristics change at short distances and are less exposed to anthropogenic activities. As a result, mountains are centers of high endemism and global biodiversity.

KEY WORDS Amanos; endemism; Taurus; flora; threatened species.

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INTRODUCTION

Very high parts of the earth's ridges (more than 500 m) are called mountain, spreading over a very wide area with a steep slope, very difficult to climb, covered with trees, shrubs, grasses or bare rocks. Just as mountains can be isolated, they can form mountain chains, mountain ranges or mountain masses in relation to each other. Mountains are the forms of the earth which are meters above the earth and which are not suitable for human life and agriculture due to the generally harsh weather conditions. There are many mountains in the world and their origin is different. While some mountains are formed by the compression of the earth, some mountains come out to the surface due to lava and freeze. The source of the lava of the volcanoes is a very warm mass called magma. 54% of Asia, 36% of North America, 25% of Europe, 22% of South America, 17% of Australia and 3% of Africa are covered with mountains. 24% of the Earth's terrestrial mass is entirely mountainous. Most of the world's rivers are fed by mountainous resources and are dependent on the mountains for more water than half of mankind. Mountains host approximately one quarter of all terrestrial biodiversity and half of the world's biodiversity hot spots (Anonymous, 2018; Barrow, 2018; Pariona, 2018).

Flatlands are generally uniform in vegetation. So a group of few plants can be seen. On the other hand, rugged terrain is rich in vegetation because it creates different environmental conditions. The

forms of the earth especially affect the elevation, the direction of the mountain's extension, the unevenness, the spread of the plants and the formation of soil (Atalay, 2002, 2006; Özkan, 2008).

A large part of the forest areas in Turkey consists of natural forests. These areas, unspoilt by foreign species, have spread up to of mountainous masses. Turkey's mountains are also very rich in endemic plants at the same time.

In terms of genetic resources, mountain ecosystems have numerous important species, and, particularly, the mountains of Turkey have many endemic herbaceous species of the Anatolian Region (Öztürk et al., 2008). For this reason, mountainous areas have an extremely important function in agricultural biodiversity.

Anatolia is a geologically young mass. However, it is one of the most active centers in all geological periods. Due to intense volcanic and tectonic activity, different environmental conditions have led to the formation of high structures in different forms (single mountains, mountain ranges, and massive mountains) in the mountainous system. In ancient Western literature, Anatolia is referred to as Asia Minor because of its high altitude.

The Alpine-Himalayan mountain belt, which started about 65 million years ago (alpine period) and formed the youngest mountain formation zone in geological terms, is the rugged mountainous area (Anonymous, 2010). Mountain ranges in Turkey are also located in this mountain belt. Twenty-four percent of the Earth's land surface consists of mountainous areas. Approximately, 78% of Turkey's national area consists of mountain areas (Anonymous, 2010, 2011). In all mountain areas, elevation, climate, soil, and vegetation characteristics change at short distances. The climate varies depending on the latitude in the horizontal direction and the elevation in the vertical direction.

Turkey has, in general, the Mediterranean macro-climate. However, there are many different types of climate, depending on the shape of the ground (Erinç, 1993). Mountainous areas create isolated environments separating from the surrounding area, resulting in increased vegetative cover and locally distributed species.

Places with different bedrock, terrestrial and soil characteristics under the influence of the same climate type show distinct ecological characteristics (Kantarcı, 2005).

Differences in soil types play a crucial role in the diversity of plant communities and in the identification of their distribution area (Avcı, 2005).

Since the early ages, humans have been in close contact with plants (Baytop, 2000). Mankind has a wide variety of interventions directly and indirectly in the ecosystem they live in. Anthropogenic effects are sometimes more important than the sum of all other ecological factors (Duran, 2013).

Mountainous areas usually have low population density. Much of these areas are not suitable for human settlement. Plant communities in mountainous areas are also less exposed to anthropogenic effects. Plant diversity is uniform in flat areas where interaction is intensive (such as field opening, grazing, fire), open to human and animal interventions. The large increase in the world population has made an impact on vegetation in the natural environment.

Because of the high level of physical isolation in high mountain peaks, deep river valleys, closed basin lakes and karstic pits, only a few species are endemic to these areas (Atalay, 2002; Eken & Ataol, 2011). Across the European continent, Turkey is one of the forested country with the highest rate (21%) (Anonymous, 2010).

In high-altitude ecosystems, precipitation, wind, evaporation, and direct solar radiation increase. However, temperature, oxygen, atmospheric pressure, and nitrogen mineralization are reduced (Güleryüz et al., 2010). In addition, different ecological characteristics of the northern and southern slopes are very different from each other, so different plant breeds are formed (Atay et al., 2009). Mountain flora survive under different environmental conditions due to their adaptive properties (hairiness, dwarfness, needle leaflet, deep root, hard leaf, cluster formation, etc.) (Kılınç & Kutbay, 2004).

Geographical isolation in mountainous areas, tectonic movements, climate changes, glacialization, strong microhabitat facilites, and evolutions increase the taxonomic richness (Körner, 1999).

In mountainous regions, rainfall, wind, air humidity, and direct radiation increase as height increases, while temperature, water vapor, and air pressure decrease and vegetation duration shortens (Duran, 2013).

The micro-habitats that characterize the mountainous areas vary according to the roughness, elevation, and slopes of the land. Due to the interactions between soil, temperature and surface,

which vary with the effect of the sun and wind, very large changes are observed at very short distances. With the effects of these changes in micro-habitats, the mountain belts contain a very rich biodiversity (Atay et al., 2009).

Many mountain ecosystems have higher species richness and endemism levels than adjacent plains. The mountains at lower altitudes can support an extraordinary biodiversity because a wide variety of ecosystems are compacted to a relatively short distance. The mountains also have suitable living areas isolated from unsuitable low plains.

Endemism levels are high, especially in the tropical regions and in the medium-height mountains in temperate regions. Mountains show environmental changes for some migratory species or represent refuge areas for other species. Mountain species with low habitat tolerance, especially those of high-altitud, are at a higher environmental risk to climate change.

Mountain environments cover 27% of the world's land surface and directly support 22% of the world's people living in mountain regions. The people of the valley are also dependent on mountain environments for a wide range of products and services, including water, energy, timber, biodiversity care, recreation and spiritual renewal opportunities. The mountains satisfy the freshwater needs of more than half of mankind and are actually the world's water towers. The mountains of the world are made up of the most spectacular landscapes, from a wide variety of species and habitat types and from diverse human communities. Mountains all over the world, in all latitudes, from hyper-arid warm desert to tropical forests, support a wide variety of ecosystems. Mountain ecosystems are important for biodiversity, especially in tropical regions and warm temperate latitudes. Isolated mountain blocks are often rich in endemic species.

In this study, the Taurus and Amanos mountains in Turkey's eastern Mediterranean region was chosen to determine the overall plant diversity and conservation status.

MATERIAL AND METHODS

Study area

The research area within the borders of Adana and Hatay province covers the geographical mountainous area within the boundaries of Erzin, Dörtyol and Iskenderun districts of the central Amanos mountains and the geographical mountainous area within the Kozan and Feke district borders of the central Taurus mountains (Fig. 1). Main settlements in the research area are Mansurlu, Burhaniye, Kalkumaç, Ergenuşağı, Bahçecik, Topaktaş, Karıncalı, Başlamış, and Üçkoz villages. Important rivers in the study area are the Zamantı and Göksu rivers, and there are İnderesi, Özerli, Deliçay and Payas creeks. The most important mountains in the study area are Tahtaflatan (2,495 m), Sarıpınar (2,081 m), Karakızoluğu (2,158 m), Sicimindağı (2,259 m), Görbeyaz (1,948 m), Mığır (2,240 m), and Harmankaya (2,208 m) (Fig. 2).

The Taurus and Amanos mountains, where the study area is located, constitute an important part of the Alpine orogenic belt that passes through the southern and eastern parts of Anatolia (Özgül, 1976). Geologically, the study area is formed from Mesozoic and Cretaceous limestone, upper Cretaceous ultrabasic rocks (Gabro and Serpentine), and Tertiary marls. Common soil formations distinguished in the area are as follows: brown calcareous soils, brown forest soils, terrarosa soils, reddish-brown Mediterranean soils, colluvial soils, and mixed land types (Akman, 1973; Türkmen & Düzenli, 1990; Karakuş & Türkmen, 2014; Türkmen et al., 2015a).

Figure 1, 2. Study area in Turkey's eastern Mediterranean Region. Fig. 1: map. Fig. 2: general views of the study area.

Low altitude parts of the research area (up to 1,200 m) have a Mediterranean climate, with warm, dry summers and cool, wet winters. The high-altitude parts of the study area (between approximately 1,200 m and 2,495 m) experience a continental climate, with cold, snowy, and rainy winters and cool, dry summers. Annual rainfall varies between 400 and 1,500 mm, depending on the elevation and direction. Seasonal rainfall regime is as follows: winter, spring, autumn, and summer. From the beginning of December until the end of March, precipitation in the form of snow is seen at places above 1,000 m. The average annual temperature of the area is 19.3 °C. In August, average maximum temperature is 34.8 °C and the minimum average temperature of 4.8 °C is seen in January (Türkmen & Düzenli, 1990; Öztürk et al., 2008; Özkan, 2008; Türkmen et al., 2015b).

RESULTS AND DISCUSSION

Our investigations on the specimens collected from the area and identified with the help of Flora of Turkey (Davis, 1965–1985; Davis et al., 1988; Güner et al., 2000) have revealed that 1,259 vascular plant taxa belonging to 469 genera from 106 families (Türkmen & Düzenli, 1990; Türkmen & Düzenli, 1998; Türkmen, 2014; Türkmen et al., 2015a, b). Author citiations of plant names followed Brummitt & Powell (1992).

The phytogeographical distribution of these taxa is as follows (Table 1): Mediterranean: 328 (26.1%), Irano-Turanian: 157 (12.5%), Euro-Siberian: 87 (6.8%), cosmopolitan and unknown: 687 (54.6%). The total number of endemic species was 195 and the endemism rate was 15.1%.

As seen in Table 1, plains (low altitudes terrains) usually have a uniform vegetation, so there are few plant species. On the other hand, mountains (steep terrains) are rich in vegetation because they create different environmental conditions.

The Mediterranean elements are dominating the list simply due to the prevalence of Mediterranean climate here. The Euro-Siberian elements, which were widely distributed in the Pleistocene ice age, have progressed southwards along the Anatolian Diagonal, and due to the humid climatic conditions, they are still continuing to grow in the research area. The Euro-Siberian floristic region in Turkey is a very widespread area with typical *Fagus orientalis* Lipsky forest formation. In the Amanos mountains, large, frequent, and pure community is distributed on the northern slopes between 1600 and 1900 m (Davis et al., 1971; Yılmaz, 1993; Türkmen & Düzenli, 1998).

The dominating families and the number of taxa these embody are: Asteraceae: 163 (12.95%), Fabaceae: 132 (10.48%), Lamiaceae: 87 (6.91%), Brassicaceae: 85 (6.75%), Poaceae: 81 (6.35%), Liliaceae: 62 (4.92%), Caryophyllaceae: 59 (4.68%), Apiaceae: 50 (3.97%), Rosaceae: 45 (3.57%), Scrophulariaceae: 44 (3.49%), Boraginaceae: 35 (2.78%); Rubiaceae: 25 (1.99%); Polygonaceae: 17 (1.35%), Euphorbiaceae: 16 (1.27%), Hypericaceae: 16 (1.27%), Orchidaceae: 16 (1.27%), Ranunculaceae: 15 (1.19%), Crassulaceae: 12 (0.95%), and Geraniceae: 12 (0.95%).

The rare and endemic species and their International Union for Conservation of Nature (IUCN) categories are as follows: CR: 1, EN: 1, VU: 15, DD: 2, NT: 12, and LC: 22 (Table 2) (Ekim et al., 2000; IUCN, 2017).

The main types of vegetation observed in the research area are maquis, forest, steppe, and aquatic vegetations (Türkmen & Düzenli, 1990; Türkmen et al. 2015a, b):

Shrub-like vegetation (macchia) is the dominant vegetation between 300 m and 600 m, most of which are evergreen shrubs. Common species include *Quercus coccifera* L., *Erica manipuliflora* Salisb., *Myrtus communis* L. ssp. *communis* L., *Cotinus coggygria* Scop., *Calicotome villosa* (Poiret) Link., *Phillyrea latifolia* L., *Olea europaea* L. var. *sylvestris* (Mill.) Lehr, P*istacia terebinthus* L. ssp. *palaestina* (Boiss.) Engl., *Cistus creticus* L., *Rham-*

Floral parameters	Number of species			Percent of sample total		
	Mount 1	Plain 1	Plain 2	Mount 1	Plain 1	Plain 2
Mediterranean elements	328	151	73	26.1	36.4	17.5
Euro-Siberian elements	157	11	7	12.5	2.7	3.9
Irano-Turanian elements	87	13	6	6.8	3.1	3.4
Multiregional elements	687	240		54.6	57.8	51.7
Endemics	195	20	8	15.1	4.8	4.5
Total flora	1259	415	1178	-	-	-

Table 1. A comparison of the floral characteristics in the research area and lowland areas (Mount 1 (present study); Plain 1 (Türkmen & Düzenli, 1990); Plain 2 (Bulut, 2008).

Endangered plants	Conservation status
Acantholimon acerosum (Willd.) Boiss. var.. *brachystachyum* Boiss.	VU (B1 a,b and B2 a,b)
Acanthus dioscoridis L. var. *laciniatus* Freyn	NT
Acanthus dioscoridis L. var. *perringii* (Siehe) E.. Hossain	VU (B1 a,b and B2 a,b)
Achillea cappadocica Hauskn. et Bornm.	LC
Achillea monocephala Boiss. et Balansa	EN (B1 a,b and B2 a,b)
Aethionema capitatum Boiss. et Balansa	NT
Aethionema schistosum Boiss. et Kotschy	NT
Alcea apterocarpa (Fenzl) Boiss.	LC
Alkanna amana Rech. fil.	DD
Alkanna cappadocica Boiss. et Balansa	LC
Alkanna kotschyana DC.	LC
Allium brevicaule Boiss. et Balansa	NT
Allium cappadocicum Boiss.	NT
Allium glumaceum Boiss. et Hauskn.	NT
Allium tauricola Boiss.	NT
Allium tchihatschewii Boiss.	LC
Alnus glutinosa (L.) Gaertn. ssp. *antitaurica* Yalt.	NT
Alyssum argrophyllum Schott	NT
Alyssum callichroum Boiss. et Balansa	LC
Alyssum corningii Dudley	NT
Alyssum huetii Boiss.	LC
Alyssum masmenaeum Boiss.	LC
Alyssum murale Waldst. et Kit. var. *haradjianii* (Rech.) Dudley	VU (B1 a,b and B2 a,b)
Alyssum oxycarpum Boiss. et Balansa	NT
Alyssum peltarioides Boiss. ssp. *virgatiforme* (Nyar.) Dudley	LC
Alyssum praecox Boiss. et Balansa var. *praecox*	LC
Anchusa leptophylla Roemer et Schultes ssp. *incana*	LC
Anthemis aciphylla Boiss. var. *aciphylla*	LC
Arenaria ledebouriana Fenzl var. *pauciflora* McNeill	LC
Asperula cymulosa (Post) Post	VU (B1 a,b and B2 a,b)
Asperula stricta Boiss. ssp. *grandiflora* Schönb.-Tem.	NT
Asperula stricta Boiss. ssp. *monticola* Ehr	LC
Asphodeline cilicica Tuzlacı	VU (B1 a,b and B2 a,b)
Astragalus antiochinus Post	DD
Astragalus campylosema Boiss. ssp. *atropurpureus* (Boiss.) Chamb.	LC
Astragalus campylosema Boiss. ssp. *campylosema*	LC
Astragalus condensatus Ledeb.	LC
Astragalus globosus Vahl	LC
Aubrieta canescens (Boiss.) Bornm. ssp. *canescens*	LC
Aubretia canescens (Boiss.) Bornm. ssp. *macrostyla* Cullen et Huber-Morat	LC
Ballota macrodonta Boiss. et Balansa	VU (B1 a,b and B2 a,b)

Endangered plants	Conservation status
Bolanthus minuartioides (Jaub. et Spach) Hub.-Mor.	LC
Bupleurum lophocarpum Boiss. et Balansa	NT
Carduus olympicus Boiss. ssp. *hypoleucus* (Bornm.) Davis	LC
Carex divulsa Stokes ssp. *coriogyne* (Nelmes) Ö.Nilsson	LC
Centaurea aladaghensis Wagenitz	EN (B1 a,b and B2 a,b)
Centaurea antitauri Hayek	VU (B1 a,b and B2 a,b)
Centaurea calcitrapa L. ssp. *cilicica* (Boiss. et Balansa) Wagenitz	NT
Centaurea cataonica Boiss. et Hausskn.	NT
Centaurea haussknechtii Boiss.	CR (B1 a,b and B2 a,b)
Centaurea lycopifolia Boiss. et Kotschy	NT
Centaurea mucronifera DC.	LC
Centaurea ptosimopappoides Wagenitz	VU (B1 a,b and B2 a,b)
Cephalaria taurica Szabo	VU (B1 a,b and B2 a,b)
Chaenorhinum litorale (Bernh.) Fritsch ssp. *pterosporum* (Fisch. et C.A.Mey.) Davis	LC
Chamaecytisus drepanolobus (Boiss.) Rothman	NT
Cicer echinospermum P.H.Davis	LC
Cirsium ellenbergii Bornm.	VU (B1 a,b and B2 a,b)
Cochleria sempervivum Boiss. et Balansa	NT
Crepis armena DC.	LC
Crepis macropus Boiss. et Heldr.	LC
Crocus cancellatus Herb. ssp. *cancellatus*	LC
Crocus kotschyanus C. Koch ssp. *cappadocicus* Mathew	NT
Cyclamen pseud-ibericum Hildebr.	EN (B1 a,b and B2 a,b)
Dactylorhiza osmanica (L.) Soo' var. *osmanica*	LC
Dianthus balansae Boiss.	LC
Dianthus brevicaulis Fenzl ssp. *brevicaulis*	LC
Dianthus lactiflorus Fenzl	NT
Ebenus laguroides Boiss. var. *laguroides*	LC
Eryngium kotschyi Boiss.	LC
Erysimum alpestre Kotschy ex Boiss.	LC
Erysimum leptocarpum Gay	EN (B1 a,b and B2 a,b)
Erysimum sintenisianum Bornm.	LC
Euphorbia cardiophylla Boiss. et Heldr.	LC
Euphorbia rhytidosperma Boiss. et Balansa	VU (B1 a,b and B2 a,b)
Ferula drudeana Korovin	VU (B1 a,b and B2 a,b)
Ferulago pachyloba Fenzl	VU (B1 a,b and B2 a,b)
Festuca adanensis Markgr.-Dannenb.	NT
Fraxinus ornus L. ssp. *cilicica* (Lingelsh.) Yalt.	LC
Galatella amani (Post) Grierson	VU (B1 a,b and B2 a,b)
Galium cilicicum Boiss.	LC
Galium stepparum Ehrend. et Schönb.-Tem.	NT
Gladiolus anatolicus (Boiss.) Stapf	LC
Graellsia davisiana Poulter	EN (B1 a,b and B2 a,b)
Haplophyllum myrtifolium Boiss.	LC

Endangered plants	Conservation status
Helichrysum arenarium (L.) Moench ssp. *aucheri* (Boiss.) Davis et Kupicha	LC
Helleborus vesicarius Aucher	NT
Herniaria argaea Boiss.	VU (B1 a,b and B2 a,b)
Herniaria. saxatilis Brummitt	VU (B1 a,b and B2 a,b)
Hieracium lasiochaetum (Bornm. et Zahn) Sell et West	LC
Hyacinthella micrantha (Boiss.) Chouard	NT
Hyacinthus orientalis L. ssp. *chionophilus* Wendelbo	NT
Hypericum aviculariifolium Jaub. et Spach ssp. *aviculariifolium* var. *avicularifolium*	NT
Hypericum avicularifolium Jaub. et Spach ssp. *depilatum* (Freyn et Bornm.) Robson var. *depilatum*	LC
Hypericum kotschyanum Boiss.	NT
Hypericum. lanuginosum *Lam. var.* scabrellum (Boiss.) Robson	LC
Inula anatolica Boiss.	LC
Isatis candolleana Boiss.	LC
Isatis constricta P.H.Davis	EN (B1 a,b and B2 a,b)
Isatis floribunda Boiss. ex Bornm.	LC
Johrenia silenoides Boiss. et Balansa	NT
Juncus sparganiifolius Boiss. et Kotschy ex Buchenau	LC
Kundmannia syriaca Boiss	LC
Lamium microphyllum Boiss.	VU (B1 a,b and B2 a,b)
Lamium garganicum L. ssp. *nepetifolium* (Boiss.) R.R.Mill	LC
Lathyrus elongatus (Bornm.) Sirj.	NT
Lathyrus. laxiflorus (Desf.) Kuntze ssp. *angustifolius* (Post ex Dinsm.) Davis	VU (B1 a,b and B2 a,b)
Leucocyclus formosus Boiss. ssp. *amanicus* (Rech. fil.) Hub.-Mor. et Grierson	NT
Linaria genistifolia (L.) Mill. ssp. *confertiflora* (Boiss.) Davis	LC
Marrubium globosum Montbret et Aucher ex Benth, ssp. *globosum*	LC
Michauxia tchihatchewii Fisch. et C.A.Mey.	NT
Micromeria cilicica Hauskn. ex P.H.Davis	EN (B1 a,b and B2 a,b)
Micromeria cremnophila Boiss. et Heldr. ssp. *amana* (Rech..f.) P.H.Davis	LC
Micromeria cremnophila Boiss. et Heldr. ssp. *anatolica* P.H.Davis	LC
Minuartia tchihatchewii (Boiss.) Hand.-Mazz.	LC
Minuartia umbellulifera (Boiss.) McNeill ssp. *umbellulifera* var. *umbellulifera*	LC
Muscari aucheri (Boiss.) Baker	LC
Muscari azureum Fenzl	LC
Muscari bourgaei Baker	LC
Muscari microstomum Davis et Stuart	VU (B1 a,b and B2 a,b)

Endangered plants	Conservation status
Nepeta isaurica Boiss. et Heldr. apud Benth.	LC
Onobrychis armena Boiss. et A.Huet	LC
Onosma armenum DC.	LC
Onosma bracteosum Hauskn. et Bornm.	LC
Onosma inexspectatum Teppner	LC
Ornithogalum alpigenum Stapf	NT
Papaver triniifolium Boiss.	LC
Paronychia argyroloba Stapf	NT
Paronychia chionaea Boiss.	EN (B1 a,b and B2 a,b)
Paronychia mughlaei Chaudhuri	VU (B1 a,b and B2 a,b)
Phlomis armeniaca Willd.	LC
Phlomis longifolia Boiss. et Bal. var. *bailanica* (Vierh.) Hub.-Mor.	NT
Phryna ortegioides (Fisch. et C.A.Mey.) Pax. et Hoffm.	NT
Potentilla calycina Boiss. et Balansa	LC
Potentilla pulvinaris Fenzl	EN (B1 a,b and B2 a,b)
Pterocephalus pinardii Boiss.	LC
Ptilostemon afer (Jacq) Greuter ssp. *eburneus* Greuter	LC
Quercus petraea (Mat.) Liebl. ssp. *pinnatiloba* (C. Koch) Menitsby	LC
Rhamnus hirtellus Boiss.	LC
Rhamnus pichleri Schneider et Bornm. ex Bornm	NT
Ricotia sinuata Boiss. et Heldr.	LC
Rindera caespitosa (A. DC.) Bunge	LC
Rosularia chrysantha (Boiss.) Tahkt.	LC
Rosularia globulariifolia (Fenzl) Berge	LC
Rumex gracilescens Rech.	NT
Salvia cryptantha Montbret et Aucher ex Benth.	LC
Salvia recognita Fisch. et C.A.Mey.	LC
Saponaria prostrata Willd. ssp. *prostrata*	LC
Satureja amani P.H. Davis	CR (B1 a,b and B2 a,b)
Satureja cilicica P.H.Davis	NT
Scabiosa kurdica Post	VU (B1 a,b and B2 a,b)
Scorzonera semicana DC.	LC
Scorzonera tomentosa L.	LC
Scutulleria glaphyrostachys Rech. fil.	VU (B1 a,b and B2 a,b)
Scutulleria rubicunda Hormem ssp. *brevibracteata* (Stapf.) Edmond	LC
Scutellaria salviifolia Benth	LC
Senecio farfarifolius Boiss. et Kotschy	LC
Senecio jurineifolius Boiss. et Balansa	LC
Sideritis cilicica Boiss. et Bal.	EN (B1 a,b and B2 a,b)
Sideritis libanotica Labill. ssp. *linearis* (Benth.) Bornm.	LC
Sideritis phlomoides Boiss.et Balansa	NT
Silene delicatula Boiss. ssp. *delicatula*	LC
Stachys longiflora Boiss. et Balansa	DD
Stachys rupestris Montbret et Aucher ex Benth.	LC

Endangered plants	Conservation status
Stachys sparsipilosa Bhattacharjee et Hub.-Mor.	LC
Tanacetum argenteum (Lam.) Willd. ssp. *argenteum*	LC
Tanacetum densum (Labill.) Schultz Bip. ssp. *amani* Heywood	LC
Tanacetum densum (Labill.) Schultz Bip. ssp. *sivasicum* Hub.-Mor. et Grierson	VU (B1 a,b and B2 a,b)
Tanacetum haradjanii (Rech.f.) Grierson	NT
Teucrium chamaedrys L. ssp. *tauricolum* Rech.f.	LC
Thesium cilicicum Bornm.	NT
Thlaspi densiflorum Boiss. et Kotschy	NT
Thlaspi rosulare Boiss. et Balansa	CR (B1 a,b and B2 a,b)
Thlaspi violascens Boiss.	LC
Thymus sipyleus Boiss. ssp. *sipyleus* var. *sipyleus*	NT
Tordylium elegans (Boiss. et Balansa) Alava et Hub.-Mor.	NT
Trifolium davisii E.Hossain	VU (B1 a,b and B2 a,b)
Tripleurospermum fissurale (Sosn.) E.Hossain	NT
Tulipa armena Boiss. var. *lycica* (Baker) Marais	LC
Verbascum antitauricum Hub.-Mor.	VU (B1 a,b and B2 a,b)
Verbascum caesareum Boiss.	VU (B1 a,b and B2 a,b)
Verbascum cheiranthifolium Boiss. var. *asperilum* (Boiss.) Murb.	LC
Verbascum cilicicum Boiss.	VU (B1 a,b and B2 a,b)
Verbascum leianthoides Murb.	VU (B1 a,b and B2 a,b)
Verbascum leianthum Benth.	NT
Verbascum linearilobium (Boiss.) Hub.-Mor.	EN (B1 a,b and B2 a,b)
Verbascum lyratifolium Koch ex Benth.	NT
Verbascum protractum Fenzl ex Tchih.	NT
Veronica balansae Stroh	LC
Veronica cinerea Boiss. et Balansa	LC
Veronica cuneifolia Don ssp. Cuneifolia	LC
Veronica dichrus Schott et Kotschy	NT
Veronica hispidula Boiss. et A.Huet ssp. *ixodes* (Boiss.et Balansa) M.A.Fisch.	NT
Veronica orientalis Boiss. Miller ssp. *nimordi* (Reichter ex Stapf.) M.A. Fischer	LC
Vicia canescens Lab. ssp. *canescens*	NT

Table 3. The endangered species of the study area and their IUCN red data list categories. *CR (B1 a,b and B2 a,b) Critically endangered: Extent of occurrence less than 5000 km^2; area of occupancy less than 500 km^2; known no more than five locations; inferred decline in the area, extent and/or quality of habitat. EN (B1 a, b and B2 a, b) Endangered: Extent of occurrence less than 100 km^2; area of occupancy less than 10 km^2; known to exist at only a single location; inferred decline in the area, extent and/or quality of habitat. VU (B1 a, b and B2 a, b) Vulnerable: Extent of occurrence less than 20,000 km^2; area of occupancy less than 2000 km^2; known no more than ten locations; inferred decline in the area, extent, and/or quality of habitat. NT Near threatened. LC Least concern. DD Data deficient.

nus oleoides L. ssp. *graecus* (Boiss et Reut.) Holmboe, R. *punctatus* Boiss. var. *angustifolius* Post, *Arbutus andrachne* L., *Daphne sericea* Vahl, *Fontanesia phillireoides* Labill. ssp. *phillireoides* Labill., and *Styrax officinalis* L.

Forest vegetation, from 300 m to 1900 m, occupies different zones depending on local climate conditions, altitude, and topographic position. The common tree species in this belt are: *Pinus brutia* Ten., *P. nigra* Arn. ssp. *pallasiana* (Lamb.) Holmboe, *Cedrus libani* A. Rich., *Abies cilicica* (Ant. et Kotschy) Carr. ssp. *cilicica* (Ant. et Kotschy) Carr., *Fagus orientalis* Lipsky, *Quercus cerris* L. var. *cerris* L., and *Carpinus orientalis* Mill.. These tree species occur in mono and mixed stands, as herbaceous and shrub layer cover is weak. Native forests of pine, cedar, and cilician fir have been overlogged and replaced with *Cistus laurifolius* L., *Juniperus excelsa* M. Bieb., *J. foetidissima* Willd., *J. drupaceae* Labill., and *J. oxycedrus* L. ssp. *oxycedrus* L.

Steppe vegetation consisting of perennial herbaceous and semi-woody dwarf plants dominate the elevation zone above 1900 m. These sparsely vegetated areas are covered by snow in winter until the middle of spring when herbaceous plants start emerging. The risk of landslides, floods, and avalanches increases due to overgrazing. The dominant species of this plant belt are: *Acantholimon libanoticum* Boiss., *Ac. armenum* Boiss. et A. Huet. var. *armenum*, *Ac. venustum* Boiss. et A. Huet var. *armenum, Allium tauricola* Boiss., *Asphodelina damascene* Boiss. et Baker ssp. *damascene* Boiss. et Baker, *Asperula stricta* Boiss. ssp. *monticola* Boiss., A*stragalus angustifolius* Lam. ssp. *angustifolius* Lam. var. *angustifolius* Lam., *As. globosus* Vahl, *As. gummife*r Labill., *As. macrourus* Fisch. et C.A.Mey., *Berberis crataegyna* DC., *Cerasus prostrate* (Labill.) Ser. var. *prostrata* (Labill.) *Ser., Convolvulus compactus* Boiss., *Cotoneaster nummularia* Fisch. et C.A.Mey., *Echinops ritro* L., *Daphne oleoides* Schreb. ssp. *kurdica* (Bornm.) Bornm., *Echinops ritro* L., *Eremurus spectabilis* Bieb., *Euphorbia kotschyana* Fenzl., *Ferula elaeochytris* Korovin, *Haplophyllum myrtifolium* Boiss., *Helichrysum arenarium* (L.) Moench ssp. *aucheri* (Boiss.) Davis et Kupicha, *Marrubium globosum* Montbret et Aucher ex Benth. ssp. *globosum*, *M. parviflorum* Fisch. et C.A. Mey. ssp. *parviflorum*, *Minuartia juniperina* (L.) Maire et Petitm., *Onobrychis cornuta* (L.) Desv, *Phlomis cap-*

itata Boiss., *Potentilla pulvinaris* Fenzl, *Pterocephalus pinardii* Boiss., *Rosa foetida* J. Herm., *R. pulverulenta* M. Bieb., *Thymus kotschyanus* Boiss et Hohen var. *glabrescens* Boiss. et Hohen., *Verbascum amanum* Boiss., and *Vincetoxicum tmoleum* Boiss.

Wetland vegetation is encountered only at creek banks and spring mouths and includes the herbaceous or woody aquatic plants such as *Alchemilla pseudocartilinica* Juz., *Alopecurus arundinaceus* Poir., *Alnus glutinosa* (L.) Gaertn. ssp. *antitaurica* Yalt., *Barbarea minor* C. Koch var. *eriopoda* Busch, *Carex divulsa* Stokes ssp. *divulsa* (Nelmes) O. Nilsson, *Cirsium arvense* (L.) Scop. ssp. *vestitum* (Wimmer et Grab.) Petrak, *Cyperus longus* L., *Datisca cannabina* L., *Equisetum arvense* L., *Hypericum venustum* Fenzl, *Juncus inflexus* L., *Lysimachia vulgaris* L., *Lythrum salicaria* L., *Nasturtium officinale* R.Br., *Orchis laxiflora* Lam., *Pedicularis comosa* L. var. *acmodonta* (Boiss.) Boiss., *Phragmites australis* (Cav.) Trin. ex Steudel, *Platanus orientalis* L., *Prunella vulgaris* L., *Ranunculus kotschyi* Boiss., *Rubus canescens* DC. var. *glabratus* (Godr.) Davis et Meikle, *Salix excelsa* J.F. Gmelin, *Scirpoides holoschoenus* (L.) Sojak, *Setaria viridis* (L.) P. Beauv., *Sium sisarum* L. var. lan*cifolium* (M. Bieb) Thell., and *Tamarix smyrnensis* Bunge.

Human activities such as dams, new road constructions, settlements, excessive grazing, illegal cutting, forest fires, mining, and summer camps are threats to the vegetation in the study area.

CONCLUSIONS

Geomorphological units are one of the most important elements limiting living habitats in nature. Areas of high biodiversity are concentrated on specific geomorphological units.

Rugged topography causes a wide variety of ecological conditions. The plant varieties that adapt themselves to these environmental conditions are also diversified. The research area is very important because it has biological diversity, pharmacological/industrial plant species, and recreation functions.

The high and rugged topography of the study area has contributed significantly to plant diversity and distribution. Large mountainous terrain leads to variability in climatic and lithological conditions. This is reflected in the plant cover. If the field investigated from the other side had formed a smoother physical surface, a plant richness could not be mentioned on this scale.

The Anatolian Diagonal, which forms the connection between the northern and southern Anatolian mountains in the formation of endemism and species richness, played an important role in the plant movement in the glacial periods and glacial warming periods by acting as a bridge for some species while creating physical obstacles for some other species (Türkmen & Düzenli, 1998; Atalay, 2006; Türkmen et al., 2015b)

In the near future, the climate change that will emerge in the region will undermine sustainable development efforts as well as affecting the phenological behaviors and living conditions of existing plant species, causing deterioration problems, especially in altitude along the Taurus and Amanos Mountains. These include the addition of anthropogenic activities such as illegal cutting, harvesting, settlement, land-clearing, overgrazing, and fire, which will inevitably change the largely preserved natural vegetation cover

Estimated climate scenarios for temperature increases will seriously threaten the life of the cryohygrophilous high-altitude plant taxon in the research area, interfering with hydrological conditions. Endemics will take full share of all these effects. Upward migrations due to warming temperatures will result in displacements in the vegetation belt here and drought-tolerant invaders from low altitudes will eventually lead to biodiversity losses (Öztürk et al., 2008; Güleryüz et al., 2010).

Mountain biodiversity faces serious and growing challenges.

The degradation of the habitat caused by non-sustainable land cleansment leads to the erosion of fertile soils and increases the avalanche, landslide, and flood threats. With this change in the habitat, rare plant and animal species can be depleted.

There are many challenges to overcome in order to use mountain biodiversity successfully and sustainably. The growing demand for water, the consequences of global climate change, tourism growth, and globalization are just a few of these challenges in the world, where the pressures of the industry and agriculture are on the rise.

Important threats of mountain ecosystems are: fire; climate change; land cover change, agricultural transformation, seismic hazards, infrastructure de-

velopment, and armed conflict. These pressures disrupt mountain environments and affect the livelihoods of ecosystem services and people connected to them. In all mountain regions, natural risks are high and the effects of poor land-use practices are particularly intense. As ecosystems that represent the complex and integrated ecology of our planet, mountain environments are necessary for the survival of the global biosphere

Globalization is not only economic. It should also include the conservation and sustainable management of vegetation in all regions and other sub-regions around the world.

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Baobabs, *Adansonia* spp. (Bombacaceae Malvaceae), around Antsiranana (Diego Suarez), northern Madagascar

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ABSTRACT Baobabs list eight species of the genus *Adansonia* L. (Bombacaceae Malvaceae). One species is endemic to mainland Africa, one to Australia and six to Madagascar. Three Malagasy species are classed by IUCN as Lower Risk/Near Threatened and three are Endangered with limited numbers under the criteria of Extent of Occurrence and Area of Occupancy. The Antsiranana (Diego Suarez) region in northern Madagascar is home to *A. madagascariensis* Baill., *A. suarezensis* H. Perrier and *A. perrieri* Capuron. These are threatened by multiple causes. Naturally low regeneration rates, deforestation, use of fuelwood and charcoal, commercial logging, livestock grazing, collection and consumption of fruit, seed collection for use in cosmetics manufacture, and illegal fires are among these threats. Ecological (unable to regenerate in situ) if not physical extinction is possible because of the low regeneration potential. In addition to direct and immediate threats, the species are vulnerable to long term climate change. Small and fragmented populations, human-wildlife conflict, climate change, invasive species, diseases, lack of conservation law enforcement and inadequate knowledge and research make the prognosis for the survival of this part of Madagascar's heritage and biodiversity not very positive.

KEY WORDS *Adansonia madagascariensis*; *A. perrieri*; *A. suarezensis*; endemic species; Malvaceae.

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INTRODUCTION

The genus *Adansonia* L. (formerly Bombacaceae, family Malvaceae) includes eight species (Baum, 1995; Wickens & Lowe, 2008). With one exception, the species are referred to in most western languages as baobab. The single indigenous mainland African species, *A. digitata* L., was described from Senegal following its "discovery" by the Frenchman after whom the genus is named (Adanson, 1791). A single Australian species, *A. gregorii* F. Muell., is commonly known as the boab: its specific name commemorates the explorer Augustus Gregory (Mueller, 1857; 1858: quoted in Baum, 1995).

The remaining six *Adansonia* species are native to Madagascar. Little - indeed almost totally - unknown until the beginning of the twentieth century, as knowledge at that time was aptly summarised as "*Except for* Adansonia madagascariensis *[...] there are other species in the genus that are still largely unknown and about which, in view of our present lack of adequate material for study, we can provide little useful information. It is therefore recommended that these species be given greater attention by explorers of this large island.*" (Baillon, 1890).

Adansonia grandidieri Baill. is perhaps the iconic species and is found in the drier areas southwest of Madagascar. It is considered "endangered"

(Ravaomanalina & Razafimanahaka, 2016) although a recent population estimate is in excess of one million individuals (Vieilledent et al., 2013). *Adansonia za* Baill. occurs through southern and western Madagascar in dry or spiny forest, savannahs and scrubland. There are fewer numbers in the north-west, where it is restricted to riverine areas. Its relative abundance and wide range do not put the species at severe risk and it is classified by IUCN as Lower Risk/Near Threatened (World Conservation Monitoring Centre, 1998a). The specific epithet "*za*" is Malagasy for the tree. Occurring from the south-west to the north-west along the western coast, *A. rubrostipa* Jum. et Perr. is found in spiny and dry forest areas. Its wide distribution means it is not at immediate risk and it is classified by IUCN as Lower Risk/Near Threatened (World Conservation Monitoring Centre, 1998b). This species was initially and provisionally named *A. fony* towards the end of the nineteenth century (Baillon, 1890).

First described in the mid 1870s (Baillon, 1876) and the first Madagascar baobab to be named, the range of *A. madagascariensis* Baill. extends from Antsiranana southwards to dry or moist forest. In 1998 it was considered as Lower Risk/Near Threatened (World Conservation Monitoring Centre, 1998c). *Adansonia suarezensis* H. Perrier occurs on a very small area west of Antsiranana (Diego Suarez) in the Baie d'Antsiranana (Diego Suarez Bay) usually on limestone soils (Baum, 1995). Its area of distribution is within the limits for Endangered status under both the Extent of Occurrence and Area of Occupancy criteria of the IUCN. Three subpopulations occur outside protected areas with another three within (designated but not necessarily established) protected areas (World Conservation Monitoring Centre, 2017). Confined to the northern tip of Madagascar, *A. perrieri* Capuron is known from five sites, only one of which has more than twelve trees. This species, not described until 1960 (Capuron, 1960), is endangered (World Conservation Monitoring Centre, 1998d).

MATERIAL AND METHODS

A review of the relevant literature pertaining to baobabs was undertaken with emphasis on the Madagascar species. A series of road transects was made in March 2018 in the Antsiranana region (Diego Suarez prior to 1975 in the approximate location of 12° S, 49° E. Transects covered the area around Diego Suarez Bay), to the north of the provincial city, to the west and southwest and in the Parc National de Montagne d'Ambre. One transect was made at the foot of Montagne d'Ambre, but the southerly area of distribution of *A. perrieri* was not otherwise covered (Fig. 1).

RESULTS AND DISCUSSION

Prior to 1995 these northen species were largely sympatric in their distribution (Fig. 1; Baum, 1995).

Adansonia madagascariensis had the widest distribution and as such was considered to be near threatened and at lower risk than the other species. The distribution of *A. suarezensis* was much more restricted than *A. madagascariensis* and it was limited to a few sites to the west of Diego Suarez Bay: in part because of its restricted distribution, but also because it was heavily exploited for fruit and timber, it was considered endangered and liable to early extinction. Due to its very restricted distribution, exploitation for wood and charcoal, eating of seeds by introduced rats, and fire, *A. perrieri* was considered the most endangered of all Malagasy baobabs.

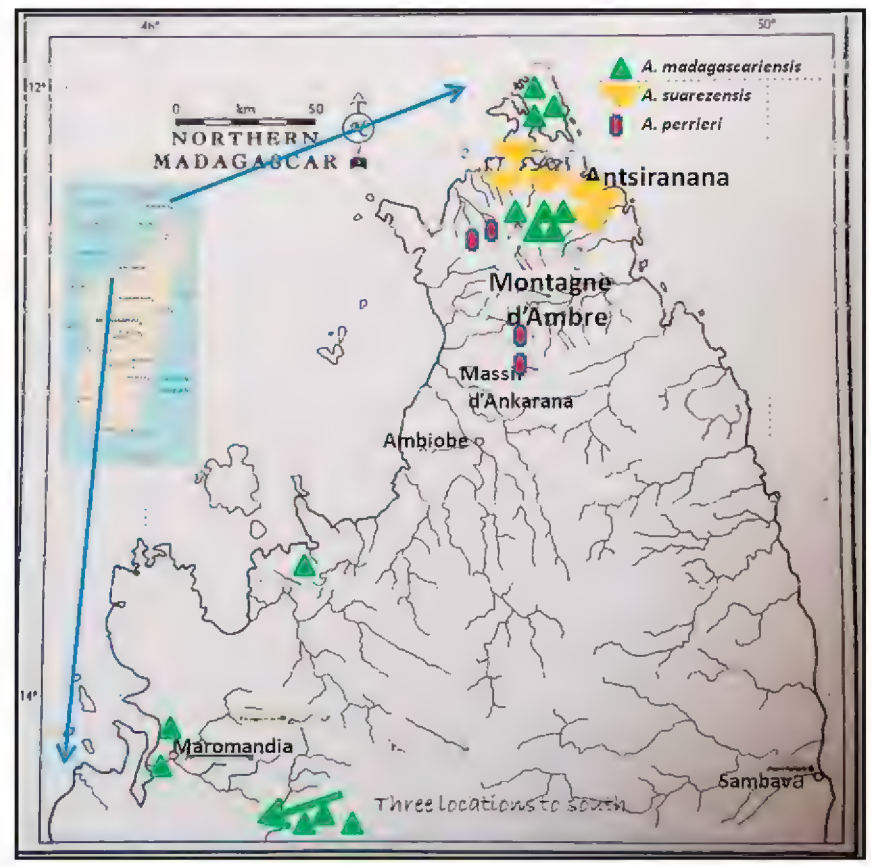

Figure 1. Outline map of northern Madagascar showing distribution of three *Adansonia* species in 1995 (adapted from Baum, 1995).

Figure 2. *Adansonia madagascariensis* planted about 1950 in the Diego Suarez Cemetery of the Commonwealth War Graves Commission; location 12°17’16.22”S; 49°17’47.42”E (photo by author).

Figure 3. *Adansonia suarezensis* on the shore line of Diego Suarez Bay in front of the “sugar loaf” volcanic plug; location 12°18’52.89”S; 49°19’7.42”E (photo by author).

During the course of this recent field study very few baobabs were seen. Among these, there were a pair of *A. madagascariensis* that had been planted some 70 years ago (i.e., around 1950) in the Diego Suarez Cemetery of the Commonwealth War Graves Commission (Fig. 2). Two specimens of *A. suarezensis* were located on the shore line of the Bay in an area cleared for cultivation and production of oil palm (Fig. 3).

Madagascar's northen baobabs are threatened by a multiplicity of causes. Deforestation in the area of occurrence has been intense since 1953 and this is likely to continue. Baobabs have a naturally low regeneration rate that is compounded by livestock grazing on seedlings, collection and consumption of fruit by people, seed collection for use in cosmetics manufacture and fires, either accidental or set by hunters to clear areas for illegal poaching of wildlife. Exploitation for fuelwood and charcoal for local household use and logging for commercial purposes are additional threats. Ecological extinction (unable to regenerate in situ) if not physical extinction is possible because of the low regeneration potential (Baum, 1995). In addition to direct and immediate threats the species are vulnerable to long term climate change (Vieilledent et al., 2013). This study shows that *A. suarezensis* in particular is vulnerable to climate change and more than half the population in the future (the years 2050 to 2080) will be in areas unsuitable for the species.

Small and fragmented populations, human-wildlife conflict, climate change, invasive species, diseases, lack of enforcement of conservation laws, and inadequate knowledge and research make the prognosis for the survival of this part of Madagascar's heritage and biodiversity not very positive.

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The Giant Asian Mantis *Hierodula tenuidentata* Saussure, 1869 spreads in Italy: a new invasive alien species for the European fauna? (Insecta Mantodea)

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ABSTRACT The presence of the Giant Asian Mantis, *Hierodula tenuidentata* Saussure, 1869 (Insecta Mantodea), is here reported for the first time in Italy. A well settled and probably wide spread population of this species is here described in detail, evaluating the increase in the number of individuals in the recent years and its adaptability to the European continental climate and to anthropized environments. The synonymy of this species with *H. transcaucasica* Brunner von Wattenwyl, 1878 is here discussed and some considerations on the potential impacts on the local ecosystems and its future spreading in Europe as an invasive species are here given.

KEY WORDS Conservation; Distribution; *Hierodula*; Alien Species; Mantodea.

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INTRODUCTION

The Giant Transcaucasian Mantis (*Hierodula transcaucasica* Brunner von Wattenwyl, 1878) originally described for the North-East of Iran, showed a typically Asian distribution until a few years ago: Afghanistan, Caucasus, Iran, Central Asia (Ehrmann, 2002; Battiston & Massa, 2008) until reaching westward the Crimea (Werner, 1916) where, however, after Werner's reporting, it was no longer recorded, if not in recent years, with a considerable presence and a potential expansion in Ukraine (Pushkar & Kavurka, 2016). In the southernmost areas of its range, it has been recorded in Eastern Turkey since the seventies (Ehrmann, 2011) approaching the Mediterranean Europe.

Between 2015 and 2018, *H. transcaucasica* was recorded as in expansion in several Balkan locations reaching the Greek islands (Cianferoni et al., 2018; Romanowski et al., in press). Until the recent expansions to the West this species has been little considered in the scientific literature: the male allotype was only described recently (Battiston & Massa, 2008) and its taxonomic identity has been rediscussed in the last years suggesting the synonymy with the Giant Asian Mantis *H. tenuidentata* Saussure, 1869 (Ehrmann, 2011; Ehrmann & Borer, 2015; Schwarz et al., 2018). The distribution of *H. tenuidentata* is traditionally located between India and Central Asia (Schwarz et al., 2018), but the synonymy with *H. transcaucasica* would expand it to Caucasus reaching the Mediterranean.

In this scenario, the doubtful attribution of some specimens recently recorded in Europe (Cianferoni

et al., 2018, van der Heyden, 2018a, 2018b), created additional confusion on this mantid, its distribution and its status of alien or native species: imported with cargos from Asia or arrived with a natural expansion from Caucasus.

The taxonomy of these mantids is here discussed presenting new data in support of the synonymy between the two species and the presence of several new records in different locations of Northern Italy. This work describes and discusses the first Italian stable and reproductive population found in the Po valley, with a first overview on its possible impacts on the local ecosystems and spread potential in Italy and Europe.

MATERIAL AND METHODS

The presence of *H. tenuidentata* was recorded in the Po Valley in two ways. First, the presence of individuals and oothecae posted or reported on social media (Facebook, Messenger, iNaturalist) was recorded and listed. In this case the observations used were verified through clear photographic material where the diagnostic characters were evident or a direct contact with the author of the observation and a following on-site verification, were possible. Second, the population located in the province of Cremona was investigated in detail, using field surveys and transects for the count of the number of specimens and oothecae in the area where the presence of this species was observed. To have a first estimate of the increase of the local population over the years, a standardized count (1 hour of slow walking) over a define transect of 900 meters has been done, recording separately the recently laid oothecae (not hatched) and the old oothecae laid in the past years (already hatched).

ABBREVIATIONS. coll. = collection; juv. = juvenes; ex/x = specimen/s; obs. = personal observation.

RESULTS

For the province of Cremona (Italy), a total of 33 individuals and 119 oothecae were recorded in an area of about 200 km^2: Calvatone: 17.IX.2018, 1 female, coll. Leandri; 17.IX.2018, 1 ootheca, obs.; 5.IX.2018, 1 female, obs.; Cingia de Botti: 12.IX.2018, 1 female, obs.; 29.VII.2018, 1 juv., obs.; 9.X.2018, 1 female, coll. Leandri; 9.X.2018, 1 ootheca, coll. Leandri; 9.X.2018, 2 oothecae, obs.; Cremona: 7.X.2018, 1 female, obs.; Drizzona: 13.VIII.2018, 1 female, 2 males, obs.; Piadena: 25.VI.2018, 1 juv., obs.; 30.IX.2018, 1 female, obs.; 5.X.2018, 3 ootheche, obs.; San Giovanni in Croce: 1.XI.2017, 1 ootheca, obs.; 10.IX.2018, 1 female, coll. Leandri; 12.IX.2018, 1 ex, coll. Leandri; 14.IX.2016, 1 female, obs.; 16.VIII.2018, 1 female, coll. Leandri; 18.VIII.2018, 1 female, obs.; 18.VIII.2018, 1 male, obs.; 19.IX.2018, 1ex, obs.; 24.VIII.2018, 1female , obs.; 24.VIII.2018, 1 juv., obs.; 26.IX.2018, 1 female, obs.; 27.IX.2018, 1 female, coll. Leandri; 27.IX.2018, 1 female, obs.; 27.IX.2018, 2 oothecae, coll. Leandri; 3.IX.2018, 1 ex., obs.; 30.IX.2018, 1 female, obs.; 5.X.2018, 103 oothecae, obs.; 5.X.2018, 5 female, coll. Leandri; 7.X.2018, 5 oothecae, obs.; 7.VII.2018, 1 juv., obs.; 14.X.2018, 1 female, obs.; Scandolara Ravara: 25.VIII.2018, 1 male, obs;

Canneto sull'Oglio (Mantova province): 28.VI.2018, 1 juv., obs.

In addition to the discovery of oothecae already hatched and laid in the past years, adult specimens have been recorded in the area since 2016, demonstrating its ability to overwinter and reproduce (Figs. 1–3) continuously with a stable population. The count of the oothecae in the transect recorded 18 oothecae laid in the past years and 69 still unhatched and undamaged, presumably laid in 2018, with an estimated increase in the population of 383% in this year over the past.

The collecting and observation areas in the province of Cremona show a marked preference of this species for the few wooded areas (Fig. 4: 75%), over the other environments included in strongly cultivated countryside landscape. Wooded strips were preferred especially as an habitat suitable for the aggregation of the females when approaching the ootheca laying time (Fig. 2). This situation is expected, since this species has repeatedly shown a preference for deposition on trees or stable vegetation, unlike for example *Mantis religiosa* Linnaeus, 1758, which seems to prefer more flat and hard surfaces such as stones or man-made artefacts (Battiston, unpublished data). Wandering individuals showed on the contrary a preference for vegetated environments but also with high anthropogenic impact such as house gardens and vegetable gardens (Fig. 5: 52%).

Figure 1. Male and female of *Hierodula tenuidentata* mating in San Giovanni in Croce (Cremona, Italy), date 18.VIII.2018. Photo C. Balestreri.
Figure 2. *Hierodula tenuidentata* laying an ootheca in San Giovanni in Croce (Cremona, Italy), date 26.IX.2018. Photo F. Leandri.
Figure 3. Group of oothecae of *Hierodula tenuidentata* just laid on *Rubus* sp. in San Giovanni in Croce (Cremona, Italy), date 5.X.2018. Photo F. Leandri.

TAXONOMICAL REMARKS

The synonymy of *H. transcaucasica* with *H. tenuidentata* has been discussed in recent years (Ehrmann, 2011; Ehrmann & Borer, 2015) in particular referring to the comparison with the female type housed in the NHMW and some specimens collected in Nepal (Schwarz et al., 2018). However these authors pointed out that a comparison with many more specimens across the distributional ranges of both species was needed to confirm this status. At present, other than approximate remarks to shape and dimensions, the only objective character useful to separate the two species: *H. transcaucasica* from *H. tenuidentata* is the presence of completely black discoidal spines on the fore femora in the first and spines black only in the tip in the latter (Giglio-Tos, 1911, 1927). In our research, by the discontinuity from their natural ranges, we examined many specimens collected in the wild coming from what is probably a single isolated population. In the natural variability of this population we examined specimens with all the possible shades in the shapes, sizes and spines: from entirely black spines to spines black only in the tip. This last character is clearly not valid to separate these species. The examination of the male genitalia of a partially black-spined specimen, resulted with no appreciable differences with the black-spined male allotype genitalia described from Caucasus (Battiston & Massa, 2008). For these reasons we decide to support the synonymy and consider *H. tenuidentata* a single species distributed from India to Europe.

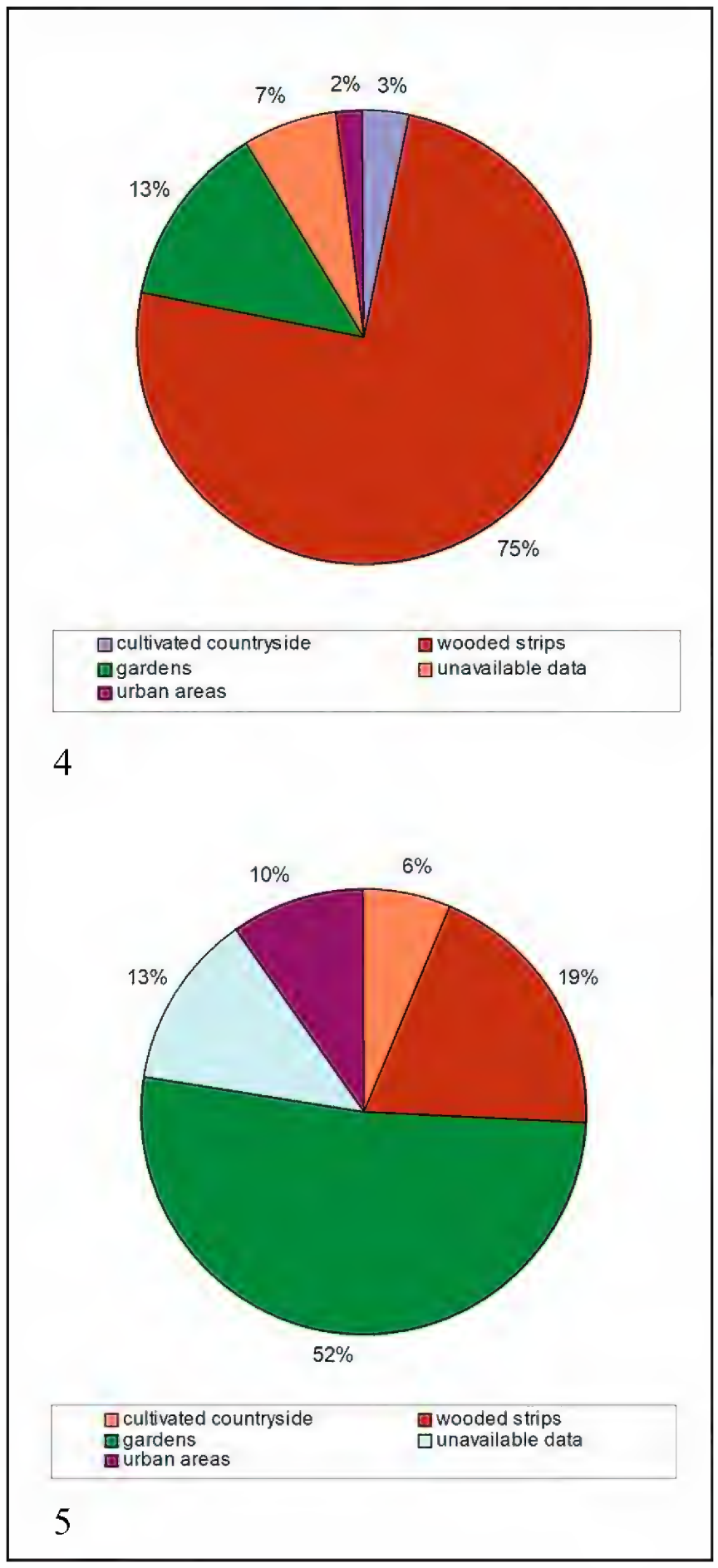

Figure 4. Habitat of the observation of individuals and oothecae of *Hierodula tenuidentata* from the Cremonese population (Italy), identified as: cultivated countryside, gardens, wooded strips, urban areas and unavailable data.
Figure 5. Habitat of the observation of wandering individuals of *Hierodula tenuidentata* from the Cremonese population Italy), identified as: cultivated countryside, gardens, wooded strips, urban areas and unavailable data.

DISCUSSION

Considering the rapid spreading of this species to the western countries in recent years, starting from the Caucasian areas to Europe, its arrival in Italy was predictable, even if the dynamics are still not clear at present. Considering the present distribution of this species in Europe ranging from Ukraine to Greece and reaching west Albania (Van der Heyden, 2018), but with the apparent absence of data for the Dalmatian area, despite the recent mantidological investigations (see e.g. Romanowsky & Romanowsky, 2014; Rebrina et al., 2014; Pavićević et al., 2014) and monitoring on social media, which would represent in some way a spatial continuity with the native range of this species, it is probable that this is not a natural expansion of the Ukraine populations but of a man-mediated transport. Since this species is not

commonly reared as pet, and therefore its voluntary release in nature seems improbable, the arrival through mercantile channels seems the most probable hypothesis, with dynamics, however, all to be ascertained. The fact that in the Cremonese area there is a vital population active since at least 2016 able to overwinter in an area characterized by a continental climate such as the Po Valley suggests that the origin is from populations located at the same latitudes, in the northernmost areas of this species, like Ukraine or the Caucasian provinces of Russia, but it is not possible to exclude a commercial route of passage for Greece, an important commercial window over the whole Mediterranean area.

The impact of this species on the Italian as well as on the European ecosystems is also currently unknown. It should however be emphasized that in the area here considered other mantid species are present: *Mantis religiosa* with a well established population and, since few years, and in smaller numbers, even the more Mediterranean dwarf mantid Ameles spallanzania Rossi, 1792, a more uncommon species, but also in a slow expansion phase from the Mediterranean towards the Continental Europe (Leandri et al., 2013). The abundance of oothecae here discovered (Fig. 3) and the well settled population of *H. tenuidentata*, are compatible if not greater than a well settled population of *Mantis religiosa*. This may presage a possible competition between these species, for space and resources, considering the strong ecological proximity of these two species, both well adapted to an already well anthropized environment and the almost perfect overlapping of the life cycle with wintering oothecae and adults active between August and October. The systematic proximity also lead to assume a possible interference in reproduction. Both are species where sexual cannibalism and attraction through pheromones, whose species-specificity is still under investigation, are well used in matings. It is known that the males of *Mantis religiosa* respond positively to the pherormonic signals coming from other mantids species, even if not phylogenetically closely related, such as *Tenodera* Burmeister, 1838 (Leito & Brown, 2008). It is therefore easy to suppose that *H. tenuidentata*, may represent a potential obstacle to the reproduction of the native species, and representing for them a real threat, as already observed in other mantid species victims of competition with invasive alien species (Fea et al., 2013).

The impact of this species on the other animals are also unknown but *Hierodula* is a voracious predator, more massive than *Mantis religiosa*, able to prey a large number of invertebrates and also small vertebrates, showing a remarkable ability to adapt to different preys and with a strong potential impact on local communities (Battiston et al., 2018). Moreover between September and October 2018 some occasional and unconfirmed records of this species have been posted on the internet in the area of Parma, continuous to the Cremonese area, showing that the presence of this species in Italy may be underestimated and ready to spread in other European countries using commercial routes. In this sense the citizen-science based monitoring is strongly encouraged to be able to follow the rapid spreading of this species.

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New *Carabus* Linnaeus, 1758 (Coleoptera Carabidae) from Caucasus and China. Description of the male of *Carabus* (*Apotomopterus*) *ebian* Cavazzuti et Rapuzzi, 2010

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ABSTRACT In this paper, five new subspecies of *Carabus* Linnaeus, 1758 (Coleoptera Carabidae) are described and figured. Three are from the south-eastern part of Sichuan province (China): *Carabus* (*Apotomopterus*) *longeantennatus transjinshaensis* n. ssp.; *Carabus* (*Apotomopterus*) *benardi briseis* n. ssp.; *Carabus* (*Acoptopterus*) *vigilax rautenstrauchi* n. ssp. The other two are from the Russian Caucasus (Ingushetia and Daghestan): *Carabus* (*Tribax*) *kasakorum daghestanicola* n. ssp.; *Carabus* (*Tribax*) *kasakorum scintillans* n. ssp. Furthermore, *Carabus* (*Apotomopterus*) *ebian* Cavazzuti et Rapuzzi, 2010 is considered a valid species after examination of a male specimen. The male aedeagus is described and figured for the first time.

KEY WORDS *Apotomopterus*; *Acoptopterus*; *Tribax*; Sichua; Caucasus; Russia; China.

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INTRODUCTION

After examination of several *Carabus* Linnaeus, 1758 specimens (*Coleoptera* Carabidae) from East Sichuan province in China and Central and East parts of the Russian Caucasus (Ingushezia and Daghestan), I have identified five new *Carabus* subspecies described in this paper. Furthermore, *Carabus* (*Apotomopterus*) *ebian* Cavazzuti et Rapuzzi, 2010 is considered a valid species after examination and description of a male specimen with the aedaegus.

Carabus (Apotomopterus) longeantennatus transjinshaensis n. ssp. (Figs. 1–3)

TYPE MATERIAL. Holotype male. China, Sichuan, Leibo, Shanlinggang env., VII.2018, Wang legit, Ivan Rapuzzi collection.

DESCRIPTION OF HOLOTYPE. Male. Length including mandibles 23.5 mm, maximum width of elytra 7.4 mm. Colour: upper and ventral side uniformly black; rather mat. Legs, palpi, antennae, and mandibles black. Head of normal shape; short neck; smooth head surface. Eyes big but moderately salient. Mandibles quite short. Palpi thin and very long, preapical segment of labial palpi bisetose. Antennae thin and very elongated protruding the apical third of elytra. Legs thin and very long. Pronotum small and narrow, nearly not transverse (1.08 times as broad as long); sides very moderately sinuate, nearly sub-parallel shape; upper surface faintly rugulose. Elytra very elongate and very narrow; convex; very narrow shoulders; quite rough sculpture, triploid slightly heterodyname type: primary chains larger and more relieved, interrupted by quite deep foveae; secondary and tertiary of the same size, uninterrupted; striae strongly punctured.

Male aedeagus typical of the species: lateral view (Fig. 2), dorsal view (Fig. 3).

ETYMOLOGY. The given name wants to emphasise its type locality situated on the opposite side of the Jinsha Jiang River where the new subspecies was found.

COMPARATIVE NOTES. *Carabus* (*Apotomopterus*) *longeantennatus* Hauser, 1931 is a polytypical species largely widespread in Central China on the right side of the Jinsha Jiang and Chang Jiang rivers (Kleinfeld, 2011; Deuve, 2013). The new subspecies is closely related with *C.* (*A.*) *longeantennatus yongshan* Kleinfeld, 1999 inhabiting on the Wulian Mountains in the Northeast Yunnan on the other side of the Jinsha Jiang River valley. From *C.* (*A.*) *longeantennatus yongshan* it differs for the slender pronotum with sub parallel sides; more elongated elytra; rough and stronger elytral sculpture; apical portion of the median lobe of male aedeagus stronger curved with more acuminate apex.

Carabus (Apotomopterus) benardi briseis n. ssp. (Fig. 4)

TYPE MATERIAL. Holotype female. China, Sichuan, Leibo, Shanlinggang environs, VII.2018, Wang legit, Ivan Rapuzzi collection. Paratypes: two females, same data as holotype in Albert Rautenstrauch collections (Augsburg, Germany).

DESCRIPTION OF HOLOTYPE. Female. Length including mandibles 38 mm, maximum width of elytra 13.3 mm. Colour uniformly slate black, quite shiny. Legs, palpi, antennae, and mandibles black. Head of medium size; short neck; head surface punctured and strongly wrinkled, front smooth. Eyes big of hemispheric shape. Very long and thin palpi, penultimate segment of the labial palpi with three setae. Long antennae protruding to the half of the elytra. Pronotum large (1.3 times as broad as long), sides regularly rounded, sinuate just before the pronotal base; very few hind angles protruding behind the base; surface of pronotum strongly and uniformly rugulose. Elytra very elongate and extremely dilated before the base; preapical tooth of elytra very long and acuminate; shoulders narrow and rounded; slightly convex profile. Sculpture of elytra triploid heterodyname type; intervals very convexs; primary intervals forming short links interrupted by large foveae; secondary forming uninterrupted costae, slightly sinuated; tertiary of smaller size, less elevated and very often interrupted forming small grains.

VARIABILITY. Very small variability. The size of the two paratypes ranges from 36 mm to 37 mm. In one paratype the elytral sculpture is characterized by less interrupted tertiary intervals.

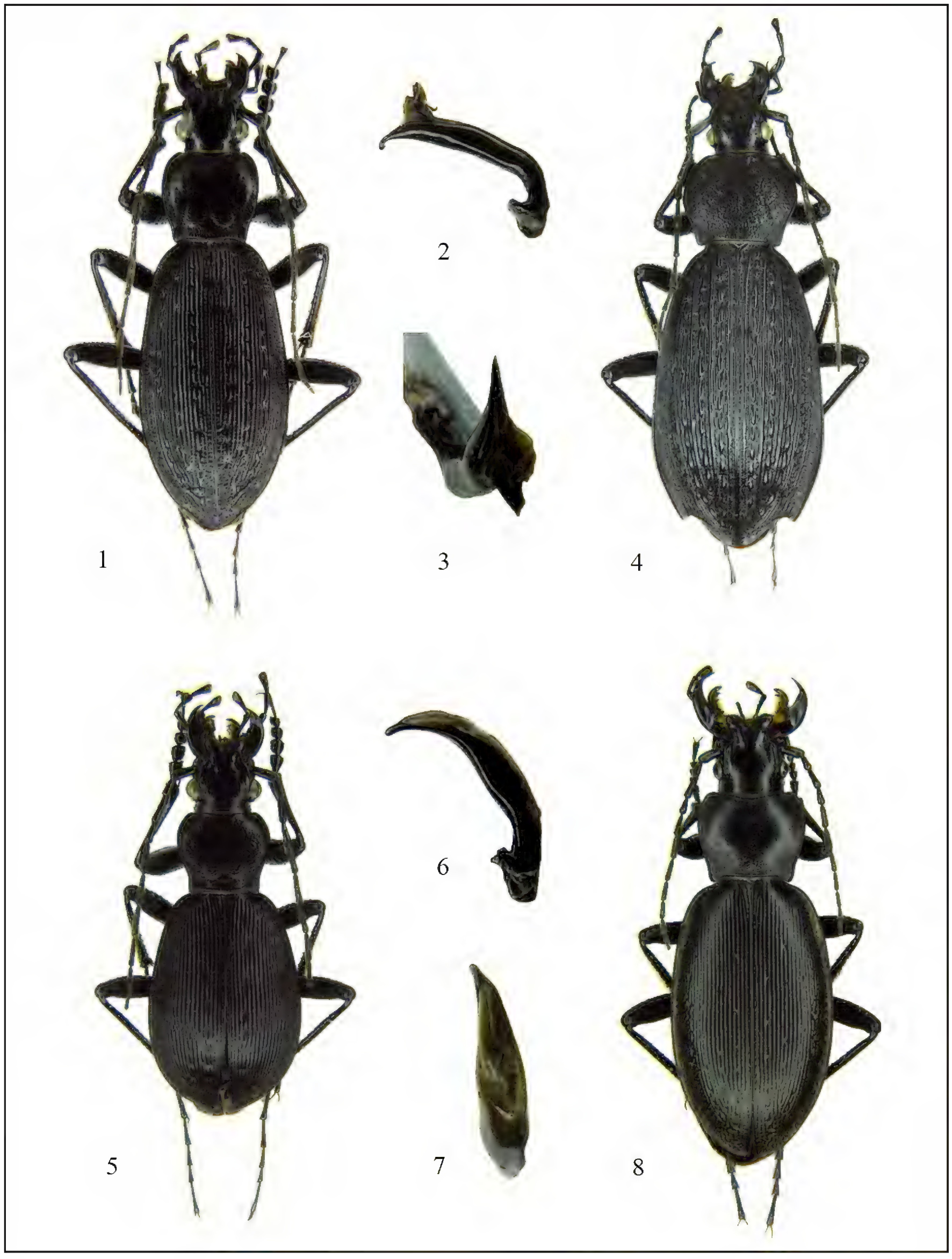
ETYMOLOGY. The new subspecies is dedicated to Briseis or Hippodameia, a mythical queen at the time of the Trojan War, and wants to follow the tradition of using classics names for the taxa belonging to the *Apotomopterus* Hope, 1838 subgenus.

COMPARATIVE NOTE. The new subspecies is close to *C.* (*A.*) *benardi yiliangensis* Deuve, 2002 but: longer and less sinuate pronotum with larger base, hind angles of pronotum less protruding behind base, elytra more elongate, elytral sculpture of heterodyname type.

Carabus (Acoptopterus) vigilax rautenstrauchi n. ssp. (Figs. 5–7)

TYPE MATERIAL. Holotype male. China, Sichuan, Leibo, Shanlinggang environs, VII.2018, Wang legit in collection Ivan Rapuzzi. Paratypes 4 females: same data as holotype, in Ivan Rapuzzi (1 female) and Albert Rautenstrauch collections (3 females) (Augsburg, Germany).

DESCRIPTION OF HOLOTYPE. Male. Length including mandibles 19.8 mm, maximum width of elytra 7.1 mm. Colour: upper and ventral sides of the body, legs, palpi, antennae, and mandibles uniformly black. Head quite thickened; disk faintly punctured, smoother front; supra antennary ridges very prominent. Big and prominent eyes. Palps very long and thin, apical segments of the labial and maxillar palps not dilated; penultimate segment of the labial palpi bi-setose. Antennae very long and thin, protruding behind the half of the elytra. Legs thin and extremely long. Small and slender pronotum (1.15 times as broad as long), sinuate; maximum width of pronotum at the apical third; sides fully margined and slightly bent upwards behind the pronotal base; hind angles of pronotum rounded and moderately protruding behind its base; surface of pronotum punctured and rough at the sides and behind the



Figures 1–3. *Carabus* (*Apotomopterus*) *longeantennatus transjinshaensis* n. ssp. Fig. 1: holotype. Fig. 2: male aedeagus in lateral view. Fig. 3: male aedeagus in dorsal view. Figure 4. *Carabus* (*Apotomopterus*) *benardi briseis* n. ssp., holotype. Figures 5–7. *Carabus* (*Acoptopterus*) *vigilax rautenstrauchi* n. ssp. Fig. 5: holotype. Fig. 6: male aedeagus in lateral view. Fig. 6: male aedeagus in dorsal view. Figure 8. *Carabus* (*Tribax*) *kasakorum daghestanicola* n. ssp., holotype.

base. Elytra oval, quite short and rounded; maximum width of elytra at the apical third; shoulders salient; sculpture triploid perfectly homodyname: primary interval forming chains of long segments interrupted by superficial foveae; secondary and tertiary interval of the same size forming uninterrupted lines; not punctured striae.

Male aedeagus is characteristic for the species but: in lateral view (Fig. 6), the apex of the median lobe is slender and more elongated. In dorsal view, the apex is very long and curved on le left (Fig. 7).

VARIABILITY. The variability concerns only the size that ranges from 21 mm to 22.1 mm.

ETYMOLOGY. The new subspecies is cordially dedicated to my friend and colleague Alber Rautestrauch (Augsburg, Germany).

COMPARATIVE NOTES. Close to *C.* (*A.*) *vigilax vigilax* Bates, 1890 but with more elongated head. Shape of elytra shorter and larger, rounded apex of elytra. Elytral sculpture of homodyname type, very regular and not rough up to the elytral apex; striae not punctate, primary foveae smaller and superficial. Apex of male aedeagus slender and more elongated.

Carabus (Tribax) kasakorum daghestanicola n. ssp. (Fig. 8)

TYPE MATERIAL. Holotype female: Russia, East Caucasus, Daghestan, Andiysky Mountain Range, Kharami pass, 2,500 m, 5.VII.2010, S. Rybalkin legit, Ivan Rapuzzi collection.

DESCRIPTION OF HOLOTYPE. Female. Length including mandibles 25.3 mm, maximum width of elytra 8.1 mm. Colour: upper surface black with cupper lustre stronger on the elytral and prontal sides; primary fovea of elytra gold; rather shiny. Legs, palpi, antennae, and mandibles black. Thickened head, surface faintly punctured; front flat; short and large neck. Eyes quite big but not salient, quite flat. Mandible long and asymmetric: the left is slender and more developed than the right; the apical tooth of the left retinacle is very smooth, large and short; right retinacle bifid. Palpi thin but quite short, preapical segment of labial palpi bisetose. Antennae thin and quite short. Short legs. Pronotum sub-quadrate, quite transverse (1.25 times as broad as long), not sinuated sides; upper surface slightly flat and uniformly punctured; margined sides, slightly bent upwards behind the pronotal base; hind angles of pronotum rounded, protruding behind its base. Elytra elongate-oval shape; elytra slightly flat; elytral sculpture triploid homodyname type, very regular, convex intervals; primary chains sparsely interrupted by small but quite deep fovea; secondary and tertiary of the same size, uninterrupted; punctured striae.

ETYMOLOGY. The new subspecies is named after the type locality.

COMPARATIVE NOTES. For its very smooth and regular elytral sculpture, the subquadrate pronotum is easily distinct from all the *C.* (*T.*) *kasakorum* Semenov, 1896 forms (*kasakorum* s. str., *tschetschenicus* Semenov, 1896 and *scintillans* n. ssp.). From *C.* (*T.*) *georgiensis* Gottwald, 1980, described as a valid species (Gottwald, 1980) and subsequently considered as a subspecies of *C.* (*T.*) *kasakorum* by Brezina (2003) or as a valid species (Deuve, 2004; Retezár, 2015), the new taxon is distinguish for the shape of pronotum (cordate in *C.* (*T.*) *georgiensis*) and the slender and elongated shape of elytra. It is morphologically similar to *C.* (*T.*) *fausti* Dohrn, 1873 inhabiting the same region, but easily distinguish by the very smooth and reduced apical tooth of the left retinacle (bifid in *C. fausti*), the smaller and flatted eyes (convex and larger in *C. fausti*), the subquadrate shape of pronotum (sinuate in *C. fausti*), the slender but less flat elytra (very flat and wider in *C. fausti*), the convex intervals of the eytral sculpture (flat and very smooth in *C. fausti*), the faint copper colour (black in *C. fausti*), the short legs and antennae (longer in *C. fausti*), and the black colour of tibiae and palpi (brown in *C. fausti*). For the significant and very specific morphological characters and for its geographical position very far to the East from *C. kasakorum* s.l., it very likely represents a different species. The examination of a male specimen will be necessary to clarify the status of this very interesting taxon.

Carabus (Tribax) kasakorum scintillans n. ssp. (Figs. 9–11)

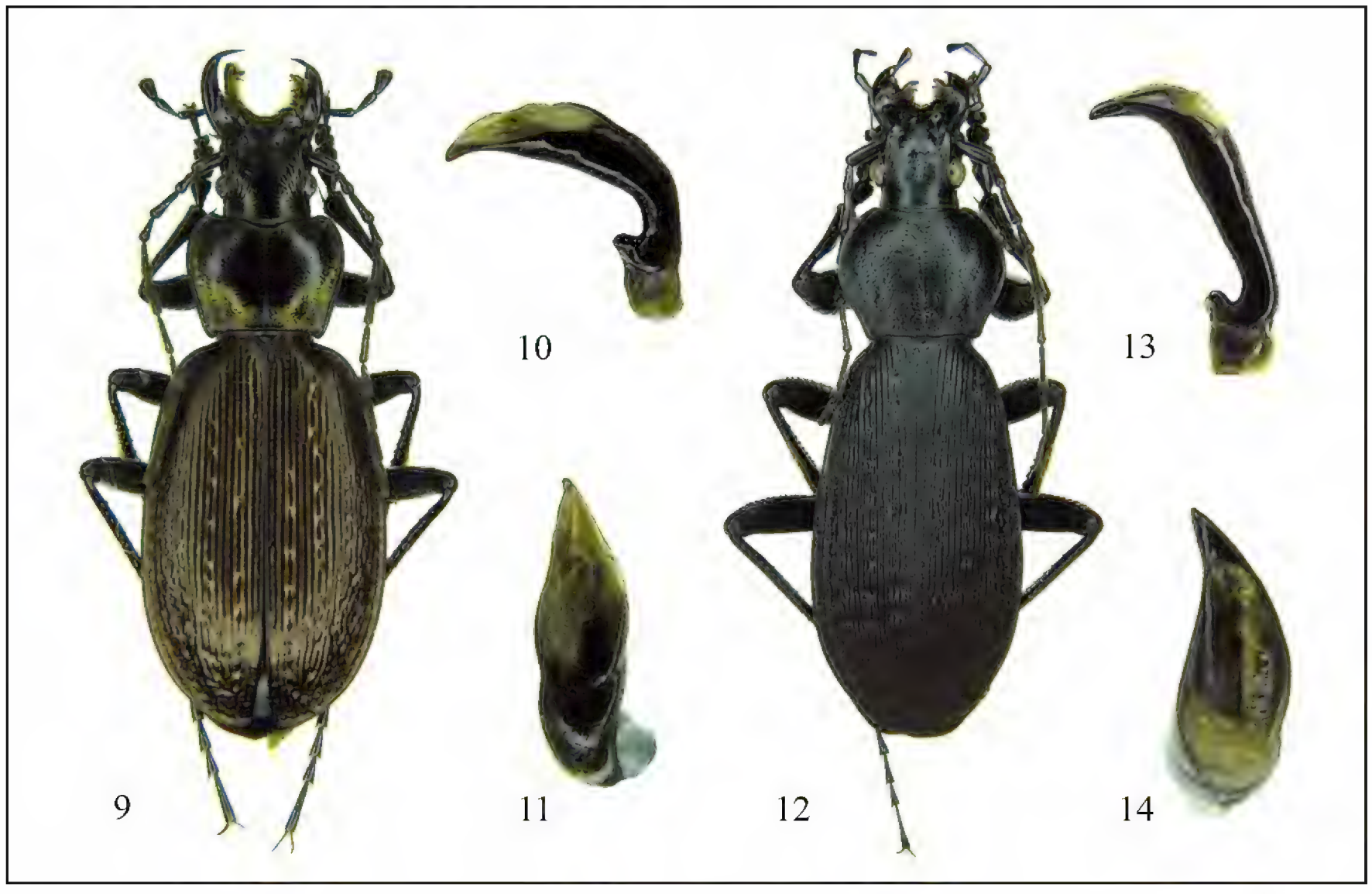
TYPE MATERIAL. Holotype male: Russia, Caucasus, Ingushetia, South slopes of Skalistyi Mountain

Range, Beyni village environs, 2,800 m, 21.V/19.VII.2018, Ivan Rapuzzi collection. Paratypes: 2 males and 3 females, same data as holotype, Ivan Rapuzzi collection.

DESCRIPTION OF HOLOTYPE. Male. Length including mandibles 22.5 mm, maximum width of elytra 8 mm. Colour: upper surface of elytra of intense copper-gold lustre, stronger on the sides and on the primary fovea; pronotum of the same colour of elytra but with darker disc; shiny. Legs, palpi, antennae, and mandibles black. Head slightly thickened; supra antennary ridges deep and wrinkled. Mandible long and strongly asymmetric: the left is slender and longer than the right; the apical tooth of the left retinacle is very smooth, large and short; right retinacle bifid, very long and thin palpi, preapical segment of the labial palpi with three setae. Antennae thin and long, reaching the half of the elytra. Legs long and quite slender. Transverse pronotum (1.49 times as broad as long), curved and not sinuated sides; very concave at the apex; upper surface wrinkled, strongly at the base; hind angles of pronotum rounded, bent downwards and protruding behind its base. Elytra of oval shape, quite short; very flat disc of elytra; large and salient shoulders; sculpture of elytra triploid type, slightly heterodyname; intervals strong and convex, rough at the apical third of elytra; primary chains of larger size, very often interrupted by large and quite deep fovea; secondary and tertiary of the same size, uninterrupted; punctured striae. Male aedeagus characteristic for the species but in general small and slender: in lateral view (Fig. 10) the apex of the median lobe is longer. In dorsal view the apex is strongly curved on le left (Fig. 11).

VARIABILITY. The variability of the paratypes concerns the size that is 21.5 mm for the paratype male and ranges from 23 mm to 25 mm for the paratypes females; the colour is copper-gold or copper-green, the females are in general darker and slightly mat.

ETYMOLOGY. The given name wants to point out the very shiny and bright colour unusual for the species.



Figures 9–11. *Carabus* (*Tribax*) *kasakorum scintillans* n. ssp. Fig. 9: holotype. Fig. 10: male aedeagus in lateral view. Fig. 11: male aedeagus in dorsal view. Figures 12–14. *Carabus* (*Apotomopterus*) *ebian* Cavazzuti et Rapuzzi, 2010. Fig. 12: male. Fig. 13: male aedeagus in lateral view. Fig. 14: male aedeagus in dorsal view.

COMPARATIVE NOTE. Very well characterized subspecies. The closest form is *C. kasakorum kasakorum* but it is easily distinguished by the followings characters: shorter but less stout head; sides of pronotum not sinuate; shorter and wider elytra, very flat disc; shiny and brighter colour; male aedeagus shorter and slender, apex longer. From *C. georgiensis* Gottwald, 1980 the new taxon differs for: larger size; not sinuated pronotum; sculpture of elytra of heterodyname type, stronger and rough; shiny and bright colour; male aedeagus larger with less curved apex.

Carabus (Apotomopterus) ebian Cavazzuti et Rapuzzi, 2010 (Figs. 12–14)

Carabus (*Apotomopterus*) *piriformis* subsp. *ebian* Cavazzuti et Rapuzzi, 2010

DESCRIPTION OF THE MALE of *C. ebian* Cavazzuti & Rapuzzi, 2010. Length including mandibles 33 mm, maximum width of elytra: 10 mm. Colour uniformly black, shiny. Legs, palpi, antennae, and mandibles black. Head of normal size but elongate; quite long neck; head surface faintly punctured and superficially wrinkled. Pronotum very large, transverse (1.45 times as broad as long); maximum width of pronotum at the middle; sides rounded; hind angles very short and rounded; surface of pronotum uniformly punctured. Elytra very elongate and slender; shoulders narrow and rounded. Sculpture of elytra triploid slightly heterodyname type; convex intervals; primary intervals a little bit larger, forming short links interrupted by foveae; secondary and tertiary of the same size forming uninterrupted costae, very slightly sinuated.

Male aedeagus in lateral view (Fig. 13) very elongate; basal and median portion rectilinear of sub-conic shape; apical portion strongly curved; apex shorter and not dilated. In dorsal view (Fig. 14) quite curved on the left.

COMPARATIVE NOTE. Cavazzuti & Rapuzzi (2010) described, on the basis of two female specimens, this taxon as a subspecies of *C.* (*A.*) *piriformis* Deuve, 1997. Thanks to the kindness of Mr. Albert Rautenstrauch, I had the opportunity to study a male specimen of this taxon collected in its type locality. After its examination, I propose to consider *C.* (*A.*) *ebian* as a different species separate from *C. piriformis* and *C. benardi* as already hypothesized by the Authors in the discussion in the original description. *Carabus* (*A.*) *ebian* differs from *C. benardi* and *C. piriformis* for the following characteristics: longer neck; more transverse pronotum, not sinuated sides; surface of pronotum slightly rugulose; hind angles of pronotum shorter and larger; male aedeagus of sub-conic shape, apical lobe shorter of sub-cylindrical shape, not dilated, apex acuminate.

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On some Pliocene Lucinidae J. Fleming, 1828 (Bivalvia) from Orciano Pisano (Pisa, Italy) with the proposal to establish a new species: *Alucinoma* (?) *persquamulosa* (Sacco, 1901)

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ABSTRACT In the present paper, three species of bivalves (Mollusca Bivalvia) belonging to the Lucinidae J. Fleming, 1828 family, coming from the Pliocene lands of Orciano Pisano (Pisa, Italy) are described and discussed. They are: *Myrtea spinifera* (Montagu, 1803), *Gonimyrtea* (?) *meneghinii* (De Stefani et Pantanelli, 1878) and *Alucinoma* (?) *persquamulosa* (Sacco, 1901). The latter species has been described as a variety of *Lucina meneghinii* and, following the new findings in the surroundings of Orciano Pisano, we propose it as a valid species. Some discrepancies with the descriptions of the type species of the various genera used in the determinations, suggest the possibility of a systematic update of the italian Pliocene lucinides.

KEY WORDS Lucinidae; *Myrtea*; *Gonimyrtea*; *Alucinoma*; Pliocene; Orciano Pisano; Tuscany.

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INTRODUCTION

Orciano Pisano (Pisa, Italy) is a village known since 1800 for fossils found in its immediate surroundings; the location is interesting, both from the historical and scientific point of view, due to the abundance and variety of remains belonging to vertebrates and invertebrates. Many authors have treated them, among many: Pecchioli (1864), D'Ancona (1871, 1872), Lawley (1875, 1876, 1879), Menesini (1977), Bianucci (1996, 1997), Gatto (1997), Dell'Angelo et al. (2000), Bianucci & Landini (2005), Danise et al. (2010), Brunetti et al. (2017), Dominici et al. (2018), Brunetti & Cresti (2018). In the course of surface searching, aimed at expanding the knowledge on the fossil malacofauna present in the study area, several mollusc shells have been collected, among which we have identified numerous Lucinidae bivalves belonging to the genus *Myrtea* W. Turton, 1822 and, with some doubts, to *Gonimyrtea* Marwick, 1929 and *Alucinoma* Habe, 1958. We attributed to this last genus a specimens originally described by Sacco (1901) as a variety of *Myrtea spinifera* (Montagu, 1803), proposing it as a new combination with the denomination of *Alucinoma* (?) *persquamulosa* (Sacco, 1901).

MATERIAL AND METHODS

Study area

As described in our recent work on the same locality area (Brunetti et al., 2017), the land around the village of Orciano Pisano (Pisa, Italy), forming part of the Fine River Basin region, consists mainly of sandy clays, sometimes accompanied, towards the upper part of the hills, by rare calcarenites. The

deposition age is between the lower Pliocene and the end of the Piacenzian (Danise et al., 2010; Dominici et al., 2018). If, on a general level, the "clays" appear at a hurried observation, similar to each other, observing the land with more attention, we can distinguish in the various hills around the country, differences in sedimentation and facies, reflected by the different content in the mollusc faunas, which sometimes can correspond to different ages within the Pliocene. The typical blue clays, from batial environment, of the lower Pliocene, are more present to the west, near the Gabbro country, where they are in continuous contact with the sediments of the upper Miocene (Bossio et al., 1981). The examined material comes from clayey sediments with sometimes a more or less evident sandy component, generally deposited at a depth corresponding to the circalittoral, of average Piacenzian age, as is shown in Dominici et al. (2018) from the position of the sections number 1, 2 and 3, corresponding to the localities of Pagliana, Pieve Vecchia and Orciano of their figure 2 (Fig. 1).

Material

The samples were obtained mainly through manual harvesting of the surface and partly from the washing and screening of sediment blocks, taken from the points where there were greater concentrations of shells. The specimens are almost always with separate valves, even if sometimes the provenance to the same individual is evident, since the two shells were very close to each other and in opposition. Often, they have the ornamentation surface corroded centrally giving the impression that the same is more evident to the sides of the shell. The few synonymous names, quoted for the species considered by us, are taken from works of a general nature or from other parts of Tuscany or relating to the locality of Orciano Pisano.

ABBREVIATIONS AND ACRONYMS. H: maximum height of the shell, measured from he top of the umbos to the opposite ventral margin; L: horizontal maximum width, distance between

Figure. 1. One of the collecting sites (red arrow) around Orciano Pisano (Pisa, Italy) corresponding to number 2, following Dominici et al. (2018).

frontal and posterior margins; vsd: loose valves, right and left, not counted; MSNF: Museo di Storia Naturale di Firenze (Italy); MRSN: Museo Regionale di Scienze Naturali di Torino (Italy); CMC: Massimo Cresti collection; MFC: Maurizio Forli collection.

RESULTS

Systematics

Classis BIVALVIA Linnaeus, 1758
Subclassis HETERODONTA Neumayr, 1884
Ordo LUCINIDA Gray, 1854
Superfamilia LUCINOIDEA J. Fleming, 1828
Familia LUCINIDAE J. Fleming, 1828
Subfamilia MYRTEINAE Chavan, 1969
Genus *Myrtea* W. Turton, 1822
Type species: *Venus spinifera* Montagu, 1803

Myrtea spinifera (Montagu, 1803) - Figs. 2–8

Venus spinifera Montagu, 1803: 577–579
Lucina astensis Bonelli - Michelotti, 1839: 25
Lucina (*Myrtea*) *spinifera* (Montagu) - Sacco, 1901: 93, tab. 21, figs. 8–23
Myrtea spinifera var. *astensis* Sacco, 1901: 94, tab. 21, figs. 11–14
Lucina (*Myrtea*) *spinifera* Montagu - Cerulli Irelli, 1909: 180–181, tab. 24, figs. 25–32
Myrtea (*Myrtea*) *spinifera* (Montagu) - Robba, 1968: 496–497, tab. 38, figs. 6a–b.
Myrtea (*Myrtea*) *spinifera* (Montagu) - Malatesta, 1974: 78, tab. 7, fig. 5
Myrtea (*Myrtea*) *spinifera* (Montagu) - Menesini, 1977: 260
Myrtea (*Myrtea*) *spinifera* (Montagu) - Brunetti, 2014: 85
Myrtea astensis (Sacco) - Brunetti & Cresti, 2018: 134, figs. 605.
Myrtea spinifera (Montagu) - Brunetti & Cresti, 2018: 134, figs. 606.

EXAMINED MATERIAL. Orciano Pisano surrondings (Pisa, Italy), Pliocene: CMC 40 vsd.; MFC 30 vsd.

DESCRIPTION. Shell equivalent, almost equilateral, outline sub-oval with posterior margin squared off, longer than high, more or less thick, compressed and slightly swollen. Prosogyrous umbo, frontal margin slightly concave, rear margin slightly convex. Small dimensions with an average width of about one and a half centimeter. Sculpture consists of concentric lamellae, regularly spaced from each other, which to anterior and posterior dorsal margins, give rise to small, spiny, squamous elevations. Hinge in the right valve with a cardinal tooth and two in the left valve; dimples at the end of the lateral teeth. External ligament. Impression of the anterior adductor muscle scar, oval with central narrowing, posterior scar subcircular; they are connected, by continuous pallial line, starting from slightly above and slightly below the respective centers. Smooth interior margin.

DISTRIBUTION. *Myrtea spinifera* is reported by the Middle Miocene (Serravalliano) of the Torinese Hills and other localities (Tortoniano) both Italian and European: Benestare (RC), Montegibbio (MO), Popogna (LI), Sant'Agata and Stazzano (AL), Vigoleno (PC); Austria, Bulgaria, France, Portugal. Pliocene and European Pleistocene. Currently widespread in the North-Atlantic, North Sea, Mediterranean, on muddy debris bottoms of the infra-circalittoral plane (Chirli, 2015: 68).

REMARKS. The species is widely present in the Pliocene lands around the village of Orciano Pisano where shells of juvenile and adult specimens are available. It is common to find it both among the faunas of the clays and the fine sands of the coasts. Some specimens fall into the "variety *astensis*" (the *Lucina astensis* of Michelotti, 1839) reported by Sacco (1901) which, in agreement with Menesini (1977), here we consider synonymous of *M. spinifera*.

Subfamilia LEUCOSPHAERINAE Taylor et Glover, 2011
Genus *Gonimyrtea* Marwick, 1929
Type species: *Loripes concinna* Hutton, 1885

Gonimyrtea* (?) *meneghinii (De Stefani & Pantanelli, 1878) (Figs. 9, 14, 17, 20–28)

Lucina bronni Mayer, 1858: 74–75, tab. 3, fig. 1
Lucina Meneghinii De Stefani et Pantanelli, 1878: 47

Lucina spinifera var. *Meneghinii* (De Stefani et Pantanelli) - De Stefani, 1888: 191, tab. 9, figs. 27–28
Lucina spinifera var. *Meneghinii* De Stefani et Pantanelli - Trentanove, 1901: 549
Dentilucina meneghini (De Stefani et Pantanelli) - Sacco, 1901: 85, tab. 20, figs. 1–4
Dentilucina meneghinii var. *persquamulosa* Sacco, 1901: 84, tab. 20, fig. 8
Phacoides (*Phacoides*) *meneghinii* (De Stefani et Pantanelli) - Robba, 1968: 495–496, tav. 38, figs. 5a-b
Gonimyrtea meneghini (De Stefani et Pantanelli) - Malatesta, 1974: 80–81, tab. 7, fig. 3
Gonimyrtea meneghini (De Stefani et Pantanelli) - Menesini, 1977: 260
Gonimyrtea meneghinii (De Stefani et Pantanelli) - Spano, 1989: 362, tab. 5, figs. 6, 7
Gonimyrtea bronni (Mayer) - Brunetti & Cresti, 2018: 134, figs. 611
Gonimyrtea meneghinii (De Stefani et Pantanelli) - Brunetti & Cresti, 2018: 134, figs. 612

TYPE MATERIAL. MSNF, IGF 8907E, Larniano (Siena, Italy), Pliocene: type, left valve, H = 8.6, L = 9; MSNF, IGF 7080E, Certaldo (Firenze, Italy), Pliocene: left valve, H = 10, L = 11; MSNF, IGF 9213E, Coroncina (Siena, Italy), Pliocene: left valve, H = 7, L = 7.8.

OTHER EXAMINED MATERIAL. MRSN, Rio Torsero (Savona, Italy), Pliocene: BS.154.03.042 (f. 8), left valve, H = 13, L = 15. Orciano Pisano surrondings (Pisa, Italy), Pliocene: CMC 30 vsd.; MFC 22 vsd.

DESCRIPTION. De Stefani & Pantanelli (1878): "*Testa suborbicularis, compressa, transversim striata; striae concentricae, distantes, prominulae, ad marginem magis perspicuae: antice et postice subquadrata; margines ventralis et dorsalis depressiusculi; margo pallearis convexus: umbones obtusiusculi: cardo parum crassus, bidentatus; fovea ligamenti magna; dentes lateraes crassiusculi*". Shell equivalent, almost equilateral, with circular, subquadrate, outline, more or less thick, compressed. Prosogyrus umbo, anterior dorsal margin short, concave, with recess accentuated under the umbo, almost straight back margin. Two not very evident ridges originate from the sides of the umbo, the anterior one ends to about half of the anterior cardinal margin, while the posterior one ends to the end of the posterior slope area. Dimensions mostly small, average width around the centimeter. Surface sculpture consists of thin and dense continuous, concentric lamellae, regularly spaced from each other, which at the edges of the valves give rise to small, spiny, scaly elevations. Hinge in the right valve with a cardinal tooth, in the left valve with two, lateral ones present in both valves. External ligament. Anterior adductor muscle scar elliptical elongated, posterior scar subrhomboidal; the pallial line begins at about half of the anterior muscle scar, ending at the lower apex of the posterior muscle scar. Whole pallial line, parallel to the margin of the valve, is crossed by serrations little evident, more pronounced just above and just below the pallial line itself.

DISTRIBUTION. Considering the inconsistencies found in the identification with *Myrtea spinifera*, some old reports from Miocene should be verified with a comparison between the specimens. For the limited purpose of this note, we merely report the distribution as found in bibliography: Miocene of the Colline Torinesi (Sacco, 1901), (Robba, 1968), Langhiano - Serravalliano of the surroundings of Cagliari (Spano, 1989). Widespread throughout the Pliocene.

REMARKS. Sacco (1901) placed this species in the genus *Dentilucina* P. Fischer, 1887, type species *Lucina jamaicensis* Lamarck, 1801, currently considered in synonymy respectively of *Phacoides* Agassiz 1846 and *P. pectinatus* (Gmelin, 1791).

The generic attribution of Sacco, and consequently that of Robba (1968), can not be maintained for the completely different characters of *P. pectinatus*, for example the strength of the shell, the different conformation of the hinge, the less evident lunula, the different pallial prints and the presence of two very pronounced external ridges extending from the umbo up to the two sides of the valves. The later more recent Authors (see synonymy) have assigned this species to the genus *Gonimyrtea* Marwick, 1929 which until recently was included in the subfamily Myrteinae Chavan, 1969. New studies based on molecular analysis have modified this situation considering in the subfamily Myrteinae the species with elongated shells not subcircular. The current species of the genus *Gonimyrtea*, on the basis of further molecular data, have been assigned to the subfamily

Leucosphaerinae Taylor et Glover in Taylor et al., 2011 (Taylor et al., 2013; Glover & Taylor, 2016).

At the moment it is difficult to give a certain general attribution to the species of De Stefani and Pantanelli; the comparison between "*Gonimyrtea*" *meneghinii* and *Loripes concinna* Hutton, 1885, a type of *Gonimyrtea* Marwick, 1929, shows morphological concordance for the "roundish" shape, the small size, the concentric lamellae ornamentation extended also in the central part of the shell, the similar shape of the adductor muscle scars and the pallial line. It differs mainly due to the presence of a recess pronounced at the lunula with relative different shape of the anterior lateral tooth. The infusion of the lunula is similar to that present in the genus *Alucinoma* Habe, 1958 (species like *Alucinoma soyoae* Habe, 1958: Japan, Sagami Bay) with which it also has in common the compressed form but the other diagnostic characters, also in this case , do not fully coincide. Since we are not specialists in this family of bivalves, we prefer to continue using the genus *Gonimyrtea*, although doubtful.

The original material comes from the paleontological collections of the Museo di Storia Naturale of Firenze (Italy). These are three Pliocene specimens, the one described and illustrated by De Stefani and Pantanelli for the establishment of their species, coming from Larniano (SI) (Figs. 9–11) and two others: one coming from the Coroncina, a locality in immediate eastern suburbs of Siena (Figs. 14–16) and another labelled as a variety of *Lucina spinifera* Montagu, coming from Certaldo (Firenze, Italy) (Figs. 17–19). The nomenclatural history of this species is short but troubled because De Stefani (1888) changed opinion about the validity of the species established with Pantanelli "*I am convinced that it is a simple variety, without pointed laminae, of* L. spinifera". The examination of the specimen indicated as variety by the Author has confirmed the correspondence with the Type and with the other coming from the Coroncina (Siena, Italy). For which, given the differences between *G. meneghinii* and *M. spinifera* (Montagu, 1803), even on a generic level, this consideration can not exist. The taxonomic validity of *G. meneghinii* has also been questioned by placing it in synonymous of *Lucina bronni* Mayer, 1858. The comparison between the original figures of the two species shows their correspondence (Figs. 12–13) but, since the name used by Mayer can not be preserved because there is a *Lucina bronni* Merian manuscript earlier cited by Braun (1843: 147) and Bronn (1843: 66) as a synonymous for *Lucina squamosa* Lamarck, 1818. The species of Mayer loses its status, as also anticipated by Sacco (1901: 85).

Malatesta (1974) reports the species for the Pliocene of Orvieto surroundings, illustrating a specimen of medium size (H = 13.2, D = 14.4), but we could not recognize it due to the poor quality of photographic reproduction (Plate VII, Fig. 3). The author, however, makes some observations about the correspondence between the description of Mayer and that of De Stefani & Pantanelli, reporting for his sample the original diagnosis of the Swiss author. Some specimens from Orciano fit well to *L. bronni*, especially to have a more rounded shape and the ornamentation is not very visible while the hinge and internal imprints are the same so in our opinion, they are not sufficiently differentiated to constitute a separate specific entity. Among the specimens we have attributed to *G.* (?) *meneghinii* we have included some that have a profile a little more rounded or with less evidence of the recess in correspondence of the lunula, (Figs 22, 24), differences that to the state current knowledge we consider falling within intraspecific variability.

Genus *Alucinoma* Habe, 1958
Type species: *Alucinoma soyoae* Habe, 1958

Alucinoma* (?) *persquamulosa (Sacco, 1901)
(Figs. 32, 36–43)

Dentilucina meneghinii var. *persquamulosa* Sacco, 1901: 85, tab. 20, fig. 7
Myrtea sp. - Brunetti & Cresti, 2018: fig. 608

TYPE MATERIAL. MRSN, Castelnuovo d'Asti (Asti, Italy), Pliocene: BS.154.03.041 (f. 7), right valve, H = 14, L = 15.8.

OTHER EXAMINED MATERIAL. Orciano Pisano surrondings (Pisa, Italy), Pliocene: CMC 40 vsd.; MFC 20 vsd.

DESCRIPTION. Shell equivalent, inequilateral, with outline almost circular, rather thick, compressed and a little swollen. Prosogyrus umbo, very

short anterior dorsal margin, rectum, right and oblique posterior margin. Pretty large dimensions, average width over two and a half centimeter. Surface with sculpture consists of dense continuous, concentric lamellae, regularly spaced from each other, which at the edges of the valves give rise to minute thorny scales. Hinge in the right valve with a cardinal tooth, in the left valve with two, short anterior lateral teeth, posterior lateral tooth lengthened according to the length of the corresponding margin. The whole hinge is poorly detectable and evident, in some specimens the dentition is obsolete. Impression of anterior adductor muscle scar, elongated ellipsoidal, posterior scar subrhomboidal; the pallial line start from about half the total lenght of the anterior scar ending to the lower apex of the posterior scar. Pallial line more or less parallel with the margin, crossed by numerous evident serrations that protrude attenuated over the entire internal surface.

DISTRIBUTION. Sacco (1901) reports it as frequent in the Miocene, Elveziano and Tortoniano, and in the Pliocene, Piacenzian and Astiano (Rio Torsero and Castelnuovo d'Asti). Considering the confusion existing in the identification of this species, so far attributed or confused with *G. meneghinii*, only the distribution for the Pliocene (Piacenzian) of Castelnuovo d'Asti and Orciano Pisano is certain.

REMARKS. The Type is established on the specimen included in the collection Bellardi and Sacco, number BS.154.03.041 (Merlino, 2007: 171), figured by Sacco (1901) at number 7 of table 20, from the Pliocene (Piacenziano) of Castelnuovo d'Asti (Piedmont) (Figs. 32–35). It is a right valve of smaller size compared to those that we estimate conspecifiche coming from Orciano Pisano, with the posterior margin partially broken for which the profile is less rounded and expanded. The muscle scars are unfortunately not very evident, the anterior coincides with that from Orciano specimens while the posterior is not visible because is almost completely covered by a label, with the original number, and residue of glue. The hinge, even if it conforms how arrangement of the cardinal and lateral teeth, it is more evident than the other individuals that we found, in which it is, on average, less evident.

Sacco (1901) distinguished his *persquamulosa* variety from *L. meneghinii* for "*lamellae squamulose-cristata concentric, etiam in medium perspicuous region*". Under this denomination, in Bellardi and Sacco collection (Sacco, 1901: tab. 20, fig. 8), there is also another specimen, numbered BS.154.03.042 (Merlino, 2007: 171), which at the moment we consider conspecific of G. meneghinii despite the profile more acute of the region ante and post umbone (Figs. 28–31).

We attribute this species dubiously to the genus *Alucinoma* Habe, 1958 mainly for the obsolete appearance of the hinge, for the similar outline of the shell and of the muscolar and pallial line impressions. Some morphological divergences such as the most evident ornamentation and the greater robustness, suggests also in this case, an uncertain generic attribution. Despite these doubts, we propose to raise the *Dentilucina meneghinii* var. *persquamulosa* with the denomination of *Alucinoma* (?) *persquamulosa* (Sacco, 1901).

CONCLUSIONS

The analysis of some Pliocene specimens belonging to the Lucinidae family, coming from the surroundings of Orciano Pisano, has shown that some taxa, although considering some intraspecific variability, need a more precise definition and attribution, at a specific and above all generic level. In light of the new methods of study of current molluscs, based in large part on genetic analysis, in addition to more careful and different ways of considering morphological characters than in the past, we believe it is necessary a revision of the fossil species belonging to this family.

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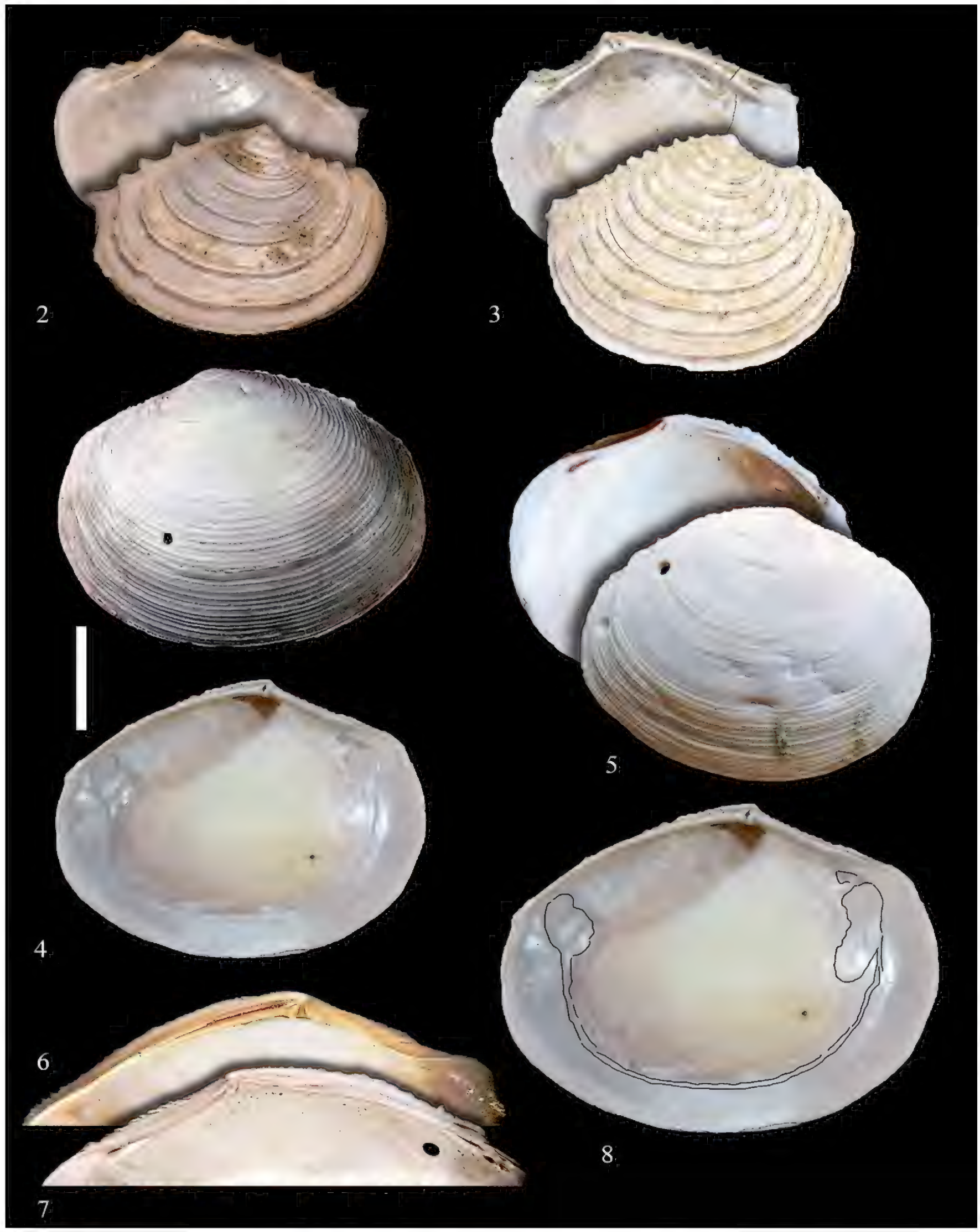
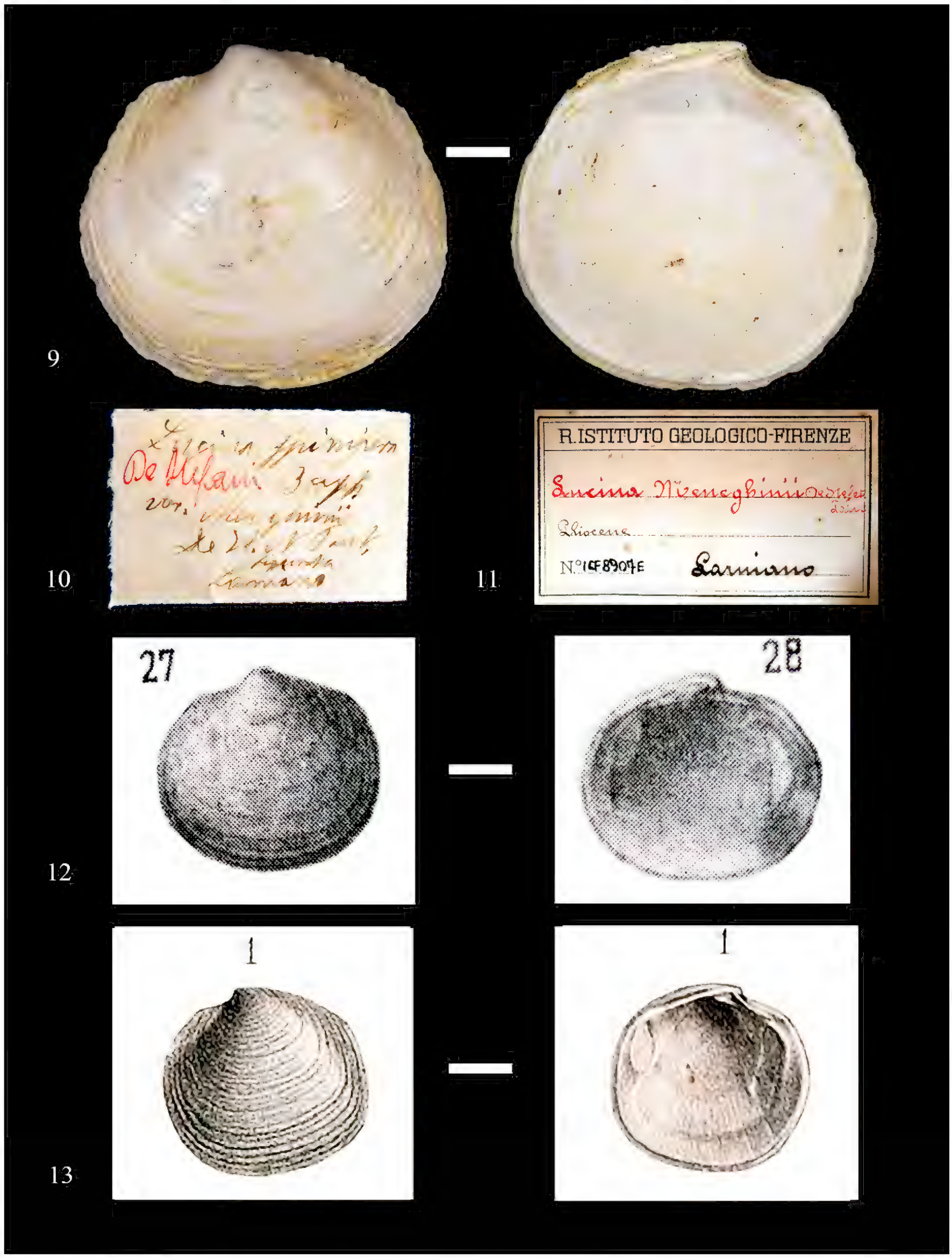
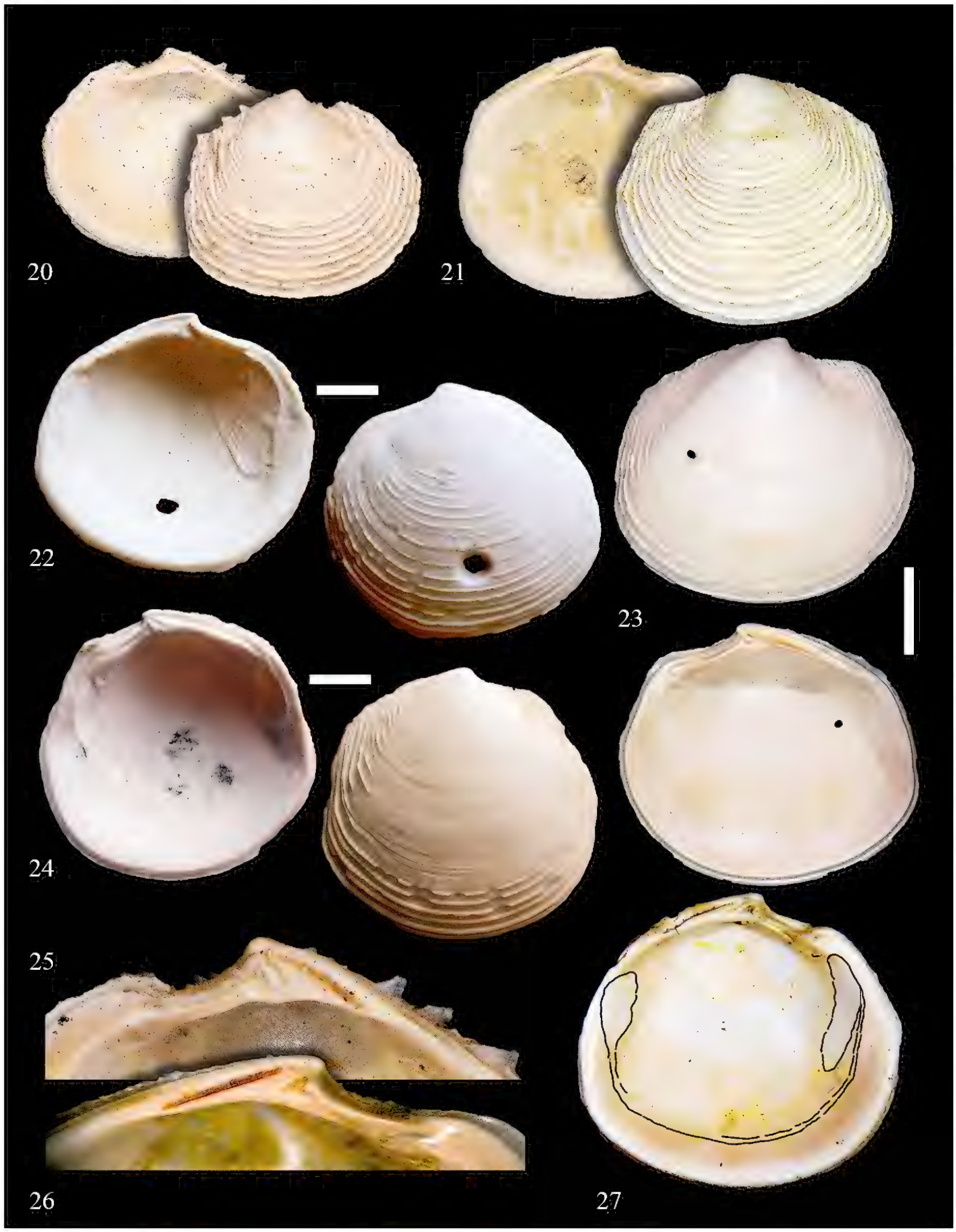


Figures 2–8. *Myrtea spinifera* (Montagu, 1803), Orciano Pisano (Pisa, Italy), Pliocene. Fig. 2: right valve, inner and upper surface, H= 2 mm, L = 4 mm. Fig. 3: right valve, inner and upper surface, H =5 mm, L = 7 mm. Figs. 4, 8: left valve, inner and upper surface, adductor muscle scars, and pallial line, H=17.2 mm, L = 23.5 mm. Figs. 5, 7: right valve, inner and upper surface, and hinge teeth, H=19.3 mm, L = 23.5 mm, morpho *Lucina astensis* Michelotti, 1839; Fig. 6: hinge teeth of the left valve, L = 18.5 mm.

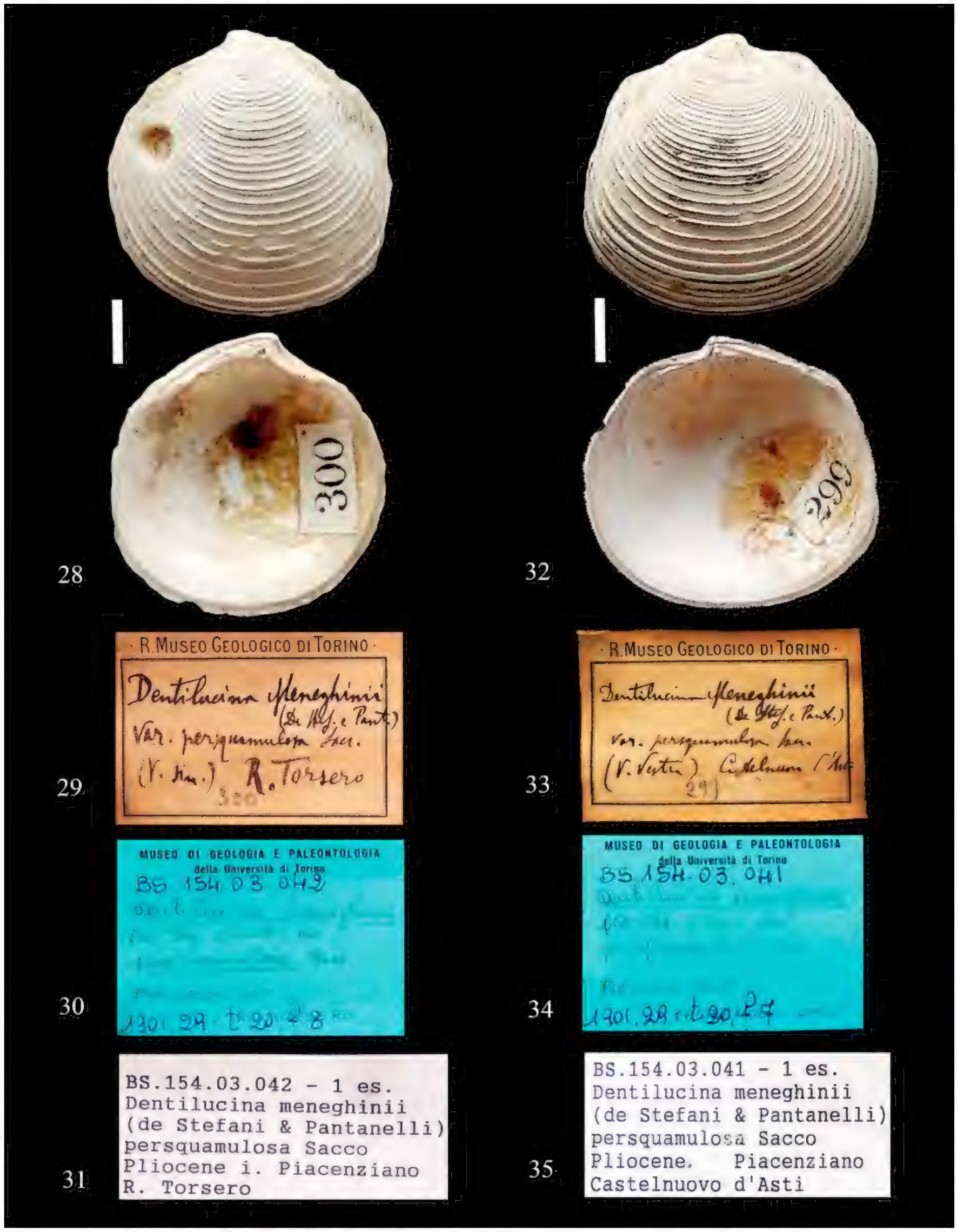


Figures 9–12. *Gonimyrtea* (?) *meneghinii* (De Stefani et Pantanelli, 1878). Fig. 9: type, left valve, H = 8.6 mm, L = 9 mm, MSNF IGF 8907E, Larniano (Siena, Italy), Pliocene. Fig. 10: original handwritten label by De Stefani. Fig. 11: label MSNF collection. Fig. 12: type specimen figured by De Stefani, 1888, p. 191, tab. 9, figs. 27-28. Figure 13: *Lucina bronni* Mayer, 1858, pp. 74–75, pl. III, fig. 1.

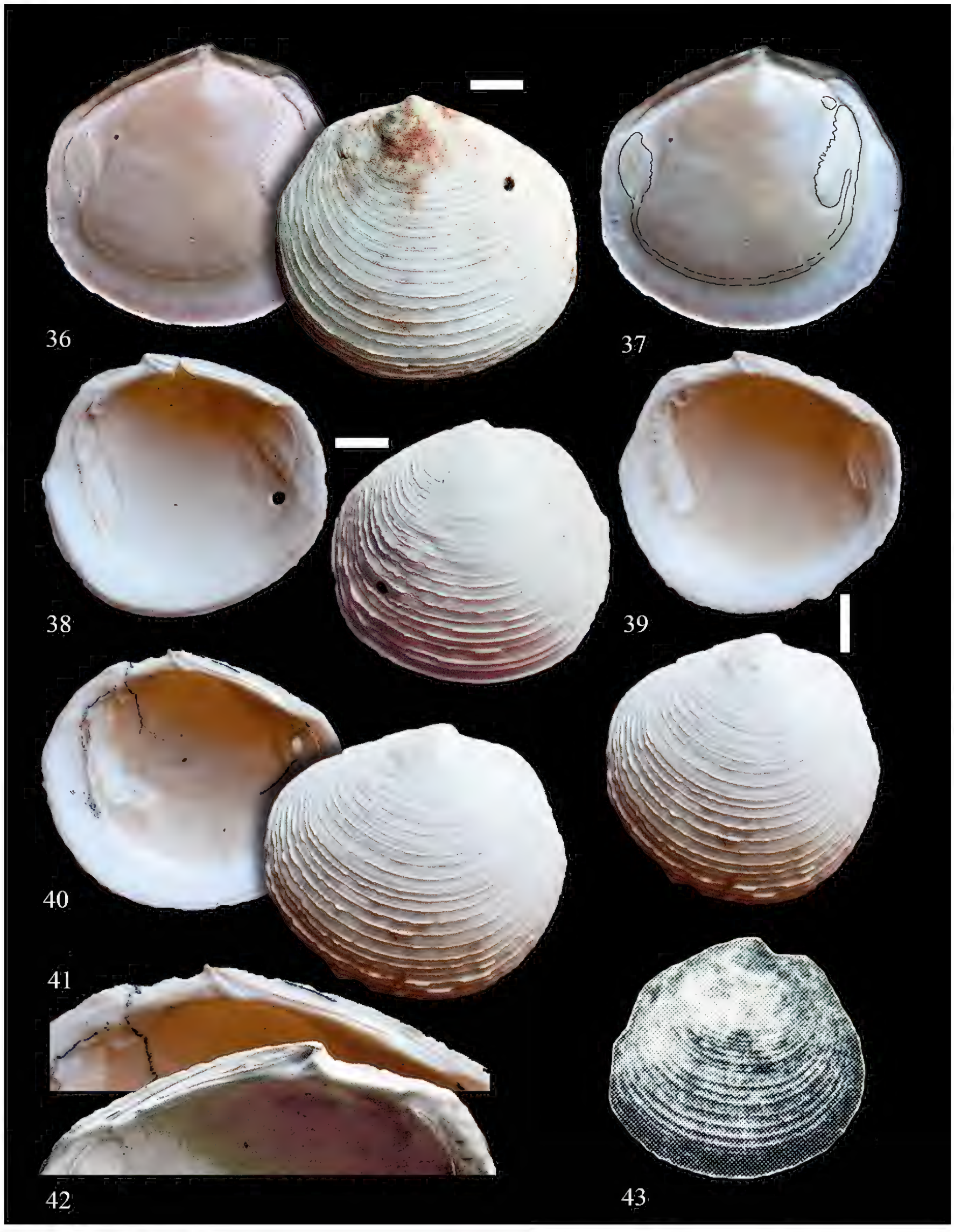
Figures 14–19. *Gonimyrtea* (?) *meneghinii* (De Stefani et Pantanelli, 1878). Fig. 14: left valve, H = 10 mm, L = 11mm, MSNF IGF 7080E, Certaldo (Firenze, Italy), Pliocene. Figs. 15, 16: original handwritten label by De Stefani and MSNF old label for specimen of figure 14. Fig. 17: left valve, H = 7 mm, L = 7.8 mm, MSNF IGF 9213E, Coroncina (Siena, Italy), Pliocene. Figs. 18, 19: original handwritten label by De Stefani and MSNF old label for specimen of figure 17.



Figures 20–27. *Gonimyrtea* (?) *meneghinii* (De Stefani et Pantanelli, 1878), Orciano Pisano (Pisa, Italy), Pliocene. Figs. 20, 25: right valve, inner and upper surface, hinge, L = 5.1mm. Figs. 21, 26: left valve, inner and upper surface, hinge, L = 9.5 mm. Fig. 22: left valve, inner and upper surface, H = 18 mm, L = 17.2 mm. Fig. 23: right valve, inner and upper surface, H = 13.7 mm, L = 15.5 mm. Fig. 24: right valve, inner and upper surface, H = 18.2 mm, L = 19.5 mm. Fig. 27: adductor muscles scars and pallial line of the specimen of figure 14.



Figures 28–31. *Gonimyrtea* (?) *meneghinii* (De Stefani et Pantanelli, 1878), Rio Torsero (Savona, Italy), Pliocene. Fig. 28: left valve, inner and upper surface, H = 13 mm, L = 15 mm. Fig. 29: original handwritten label from the Bellardi & Sacco collection; Figs. 30, 31: MRSN labels collection; Figures 32–35. *Alucinoma* (?) *persquamulosa* (Sacco, 1901), Castelnuovo d'Asti (Asti, Italy), Pliocene. Fig. 32: right valve, inner and upper surface, H = 14 mm, L = 15.8 mm. Fig. 33: original handwritten label from the Bellardi & Sacco collection; Figs. 34, 35: MRSN labels collection.



Figures 36–42. *Alucinoma* (?) *persquamulosa* (Sacco, 1901), Orciano Pisano (Pisa, Italy), Pliocene. Figs. 36, 37: left valve, inner and upper surface, adductor muscles scars and pallial line, H = 20.6 mm, L = 26 mm. Fig. 38: right valve, inner and upper surface, H = 19 mm, L = 20.2 mm. Fig. 39: right valve, inner and upper surface, H = 20 mm, L = 21.4 mm. Figs. 40, 41: right valve, inner and upper surface, hinge, H = 20.4 mm, L = 23.7 mm. Fig. 42: left valve, inner and upper surface, hinge, H = 18.6 mm, L = 22 mm; Figure 43. *Dentilucina meneghinii* var. *persquamulosa* Sacco, 1901: 85, tab. 20, fig. 7.

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Fecundity and length-weight relationship of cyprinid fish, *Rasbora rubrodorsalis* Donoso-Büchner et Schmidt, 1997 (Pisces Cyprinidae) in the tributary of Sieo River, Roi Et Province, Northeast Thailand: a preliminary report

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ABSTRACT The present paper reports on fecundity and length-weight relationship of cyprinid fish, *Rasbora rubrodorsalis* Donoso-Büchner et Schmidt, 1997 (Pisces Cyprinidae) in the tributary of Sieo River, Mun Basin, Roi Et Province, Northeast Thailand. This study indicates that length-weight relationship is related by the equation, $W = 0.0025SL^{1.52}$, ($R^2 = 0.85$). Fecundity ranged from 155–784 eggs. Fecundity-length relationship was related by the equation, $Fe = 2.2014SL^{1.56}$; ($R^2 = 0.85$) and Fecundity–weight by $Fe = 901.0637W^{0.91}$; ($R^2 = 0.78$).

KEY WORDS *Rasbora rubrodorsalis*; Fecundity; length-weight relationship; Thailand.

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INTRODUCTION

The Sieo River is a tributary of Mun River Basin. Sieo River originates at Nong Bor reservoir, Borabu District, Maha Sarakham Province, Northeast Thailand. This river system runs through several district, including Wapi Pathum District, Pathum Rat District, Kaset Wisai, Suvarnabhumi, Phon Sai, and Phanom Prai. In addition, the river flows to the Mun River Basin at Rasi Salai District, Si Sa Ket Province, Northeast Thailand with a total length of about 250 kilometers. Sieo River is one of the major rivers of Roi Et Province and a very important river basin, but very little is known about aquatic resources in this area, including biological data of fish populations.

The freshwater cyprinid fish genus, *Rasbora* Bleeker 1859 (order Cypriniformes Bleeker, 1859, family Cyprinidae Cuvier, 1817) has been reported from Indian Subcontinent to Southeast Asia (Blyth, 1860; Talwar & Jhingran, 1991; Doi, 1997; Kottelat, 2013). *Rasbora rubrodorsalis* Donoso-Büchner et Schmidt, 1997 is a small cyprinid fish widely distributed in Southeast Asia. In Thailand, the fish is reported from Chao Phraya Basin, Mekong Basin, Meklong-Petchaburi Basin, Southeast Basin, and Peninsular Basin (Vidthayanon et al., 1997). In this region, its biological data are poorly known in the natural habitat, such as feeding habit, spawning season, growth rate, fecundity, and others.

A survey project aimed at studying freshwater fishes in the tributary of Sieo River, Mun Basin, Roi

Et Province, Northeast Thailand was carried out in October 2018. *Rasbora rubrodorsalis* specimens were collected, using beach seine, along with other fishes including *Amblypharyngodon chulabhornae* Vidthayanon et Kottelat, 1990, *Esomus metallicus* Ahl, 1923, *Rasbora borapetensis* Smith, 1934, *Puntius brevis* (Bleeker, 1849), *Oryzias songkhramensis* Magtoon, 2010, *Trichopsis schalleri* Ladiges, 1962, *Trichopsis vittata* (Cuvier, 1831), *Trichopodus trichopterus* (Pallas, 1770), *Anabas testudineus* (Bloch, 1792), and others. The purpose of this study is to provide new preliminary data on the biology of *R. rubrodorsalis*.

MATERIAL AND METHODS

Field study was carried out October 2018. Thirty-three specimens of mature female cyprinid fish, *R. rubrodorsalis*, were collected using beach seines (1x1 mm) in an irrigation canal, a tributary of Sieo River, Mun River Basin at Pathum Rat District, Roi Et Province, Northeast Thailand (Fig 1). The length-weight relationship and the fecundity have been studied as reported by Krebs (1998).

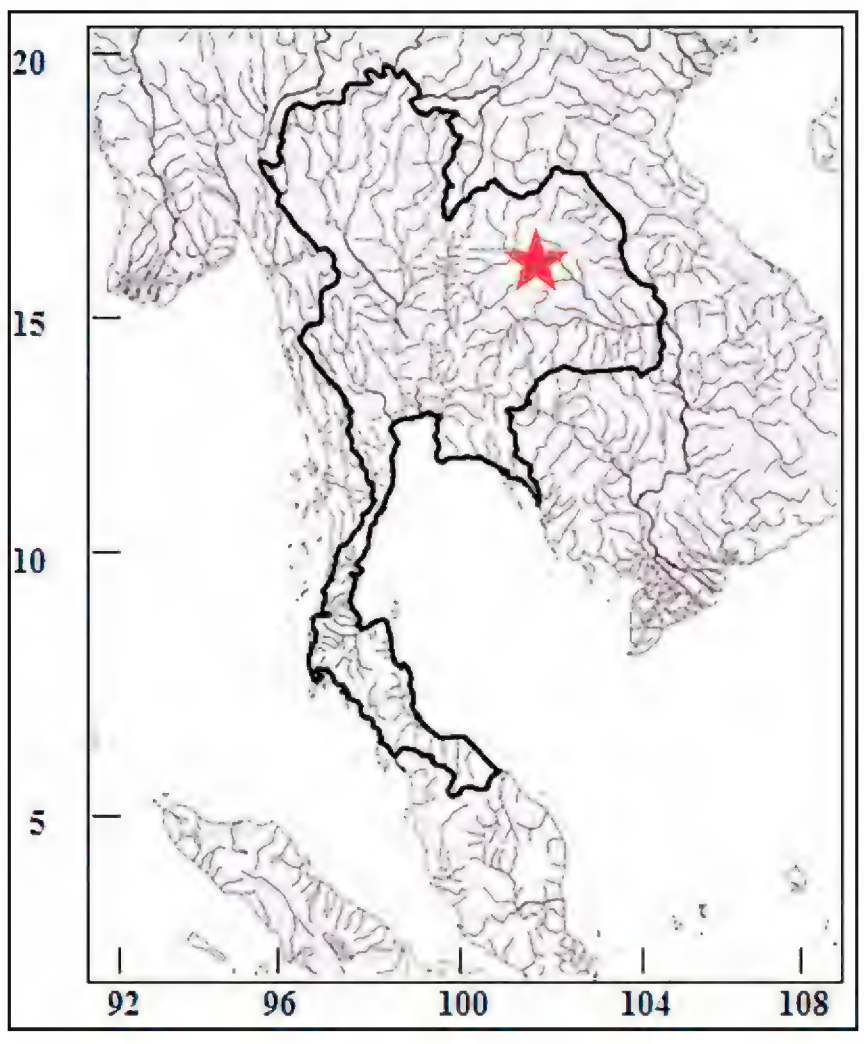

Figure 1. Study area: tributary of Sieo River, Roi Et Province, Northeast Thailand.

RESULTS AND DISCUSSION

Length-Weight relationship

From all specimens, 33 mature females (Fig. 2) have been collected. Standard length ranged from 17 mm to 39 mm (mean ± *SD*: 25.49 ± 6.22) and weight from 0.2 to 0.7 grams (mean ± *SD*: 0.36 ± 0.17). The length–weight relationship equation (mature females) was: $W = 0.0025SL^{1.52}$, ($R^2 = 0.85$) where, W = weight of specimens (g); SL = standard length of specimens (mm)

Fecundity

Data from 33 mature females have been collected. Fecundity ranged from 155–784 eggs (mean ± *SD*: 360.24 ± 157.88). Relationships were estimated between fecundity and standard length and weight, respectively. Fecundity–Length relationship: $2.2014SL^{1.56}$; ($R^2 = 0.85$) where Fe = fecundity of specimens (eggs); SL = standard length of specimens (mm). Fecundity–Weight relationship: $Fe = 901.0637W^{0.91}$; ($R^2 = 0.78$) where, Fe = fecundity of specimens (eggs); W = weight of specimens (g).

According to this study, it has been found that October, 2018, was the period of time when *R. rubrodorsalis*, during their reproductive period, had been easily found and there were a lot of them living in Sieo River. The general characteristics of the water source where they have been found is a small canal with a water level of more than 1 meter in rainy season, whereas there would be quite less water in other seasons. During the time when the samples have been collected, the water source in the studying area was characterized by being transparent, with the depth of about 30 centimeters, a lot of water plants were found. It was also the living site of many kinds of small freshwater fishes. Most of them were *A. chulabhornae*, secondly *O. songkhramensis*, followed by *R. borapetensis*. This is consistent with the study of Petsut et al. (2016), who found that during September–October of every year, *R. rubrodorsalis* often move from the main river into the small water source or temporary water source such as rice field districts, or small irrigation canals. Most of them are found in the area filled with water plants, as it is appropriate for them to lay eggs. The properties of water that is appropriate as the living site of *R. rubrodorsalis* according to

Figure 2. *Rasbora rubrodorsalis*, mature females, 34 mm SL, from tributary of Sieo River, Northeast Thailand.

the report of Petsut et al. (2016) are as follows: temperature of 31.0–33.5 Degree Celsius, pH of 6.35–7.32, total ammonia amount of 0.043–0.045 milligram/liter, nitrite of 0.160–0.616 milligram/liter, nitrate of 0.461–0.499 milligram/liter, and orthophosphate of 0.020–0.022 milligram/liter.

Morioka et al. (2014) reported the study result related to growth rate, age, and reproduction of *R. rubrodorsalis* in Laos and that the *R. rubrodorsalis*'s reproduction is "size sexual dimorphism". This means that when it is smaller, the *R. rubrodorsalis* would be male, but when it grows, it would become female. Therefore, the female samples include only the large-size samples. This indicates that females grow larger than males. In this study, it was found that the female fish's size during the reproductive period would be 17 millimeters to 39 millimeters (mean ± SD: 25.49 ± 6.22) and weight from 0.2 to 0.7 grams (mean ± SD: 0.36 ± 0.17) with fecundity ranged from 155–784 eggs (mean ± SD: 360.24 ± 157.88). This is similar to the study results in Laos. Also, Morioka et al. (2014) reported that *R. rubrodorsalis* in natural water sources are omnivorous, as their main feed includes zooplankton (copepods, rotifers and daphnids) and aquatic insects.

CONCLUSIONS

Preliminary data discussed herein suggest that length and weight of cyprinid fish, *R. rubrodorsalis* in Roi Et Province, Northeast Thailand is related. Fecundity (155–784 eggs) was found to be related to body length and weight.

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A revision of the Mediterranean Raphitomidae (*Gastropoda, Conoidea*), 7: on the sibling species *Raphitoma densa* (Monterosato, 1884) and *R. griseomaculata* n. sp.

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ABSTRACT A new raphitomid toxoglossa, *Raphitoma griseomaculata* n. sp. (Gastropoda Conoidea), is described from the Ionian Sea. It is the sister species to *R. densa* (Monterosato, 1884) from which it differs in the different protoconch (paucispiral vs. multispiral), adding to a long list of pairs of the cenogastropod species that differ in their larval development.

KEY WORDS *Raphitoma*; sister cryptic species; new species.

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INTRODUCTION

The Raphitomidae Bellardi, 1875 are currently considered as a well supported clade of the Conoidea (Bouchet et al., 2011), worthy of family ranking. It is probably the most diverse family of Conoidea, in terms of species richness, ecological range and anatomical disparity (Kantor & Taylor, 2002), and are therefore considered as potentially ideal candidates for toxin discovery (Puillandre et al., 2014).

We are currently revising the Raphitomidae of the Mediterranean Sea and the adjacent Atlantic coasts, of which we provisionally estimated ca. 47 Mediterranean extant species, some of which still undescribed. The taxon Raphitomidae Bellardi, 1875 is based on the genus *Raphitoma* Bellardi, 1847 which was introduced as comprising 34 fossil and Recent species (Bellardi, 1847: 85), previously classified in various genera (such as *Pleurotoma* Lamarck, 1799 and *Clathurella* Carpenter, 1857). During this revision, we have found several pairs of species in the genus *Raphitoma*, differing only or mostly in the size and shape of the protoconch, with one member bearing a multispiral protoconch and the other member with a paucispiral protoconch. The specific distinction is based on the assumption that the dichotomy multispiral protoconch/planktotrophic development vs. paucispiral protoconch/lecithotrophic development (Jablonski & Lutz, 1980) can be used in caenogastropods to recognise distinct sister species (Bouchet, 1989; Oliverio, 1996a, 1996b, 1997). However, it should not be abused to create polyphyletic genera by artificially separating closely related species among different genera only based on their larval development (Bouchet, 1990). In raphitomids, the separation of *Raphitoma* (multispiral protoconch) and *Raphitoma* a (paucispiral protoconch) is thus inconsistent and must be rejected.

In a recent paper (Manousis et al., 2018), it is suggested an intriguing hypothesis about a possible poecilogony in Raphitomidae, but unfortunately no evidences are showed.

In the genus *Raphitoma* Bellardi, 1847, we have scored a dozen of such pairs of species with different protoconchs (multispiral vs. paucispiral) (Giannuzzi-Savelli et al., 2018).

In the present work, we present the case of *Raphitoma densa* (Monterosato, 1884) of which we have examined the type material and selected a lectotype with multispiral protoconch and its unnamed sister species with paucispiral protoconch.

MATERIAL AND METHODS

Our approach was exclusively based on shell morphology due to the almost total lack of anatomical data.

Specimens were studied from materials housed at several European museums and from private collections (see abbreviations). Unless otherwise stated, the shells originated after sorting bioclastic sand samples collected between 0–80 m depth.

SEM images were taken by Andrea Di Giulio at the "LIME" (Interdepartmental Laboratory of Electron Microscopy - Roma Tre University). Light photographs were taken (if not otherwise stated) by Stefano Bartolini using a Canon EOS 400D digital photocamera, with standard objective 50 mm + adapted objectives (25 and 12.5 mm) for 16 and 8 mm vintage cine camera and by Riccardo Giannuzzi Savelli using a Canon EOS 45D mounted on a Kyowa binocular microscope, assembled with Helicon Focus 6 software and background removed with Clipping Magic.

ABBREVIATIONS AND ACRONYMS. Institutions. HUJ: Hebrew University of Jerusalem (Israel); MCZR: Museo Civico di Zoologia, Roma (Italy); MNHN: Musée Nationale Histoire Naturelle, Paris (France); MRSNT: Museo Regionale Storia Naturale, Terrasini (Italy); SMF: Senckenberg Museum, Frankfurt/M (Germany); SMNH: Swedish Museum of Natural History, Stockholm (Sweden). Collections. AHU: José Ahuir (Spain), BAR: Stefano Bartolini (Firenze, Italy); CAR: Alberto Caruso (Sapri, Italy); COL: Giuseppe Colamonaco†; CRO: Paolo Crovato (Napoli, Italy); DES: Flavio De Santis (Roma, Italy); DON: Mauro Doneddu (Tempio Pausania, Italy); DUR: Sergio Duraccio (Napoli, Italy); FIO: Angelo Fiorita (Lecce, Italy); GER: Alfio Germanà (Trecastagni, Italy); GIR: Antonio Girgenti (Palermo, Italy); MAC: Gabriele Macrì (Lecce, Italy); MAR: Alessandro Margelli (Santa Maria al Monte, Italy); MEL: Nicola Melone (Bari, Italy); NOF: Italo Nofroni (Roma, Italy); OLI: Marco Oliverio (Roma, Italy); PAG: Attilio Pagli (Lari, Italy); PAL: Alberto Palmeri (Palermo, Italy); PAO: Paolo Paolini (Livorno); PIS: Michele Pisanu (Quartu S. Elena, Italy); PUS: Francesco Pusateri (Palermo, Italy); RAV: Alessandro Raveggi (Firenze, Italy); RUF: Stefano Rufini (Anguillara Sabazia, Italy); SER: Gabriele Sercia (Palermo, Italy); SMR: Carlo Smriglio (Roma, Italy); SOS: Maurizio Sosso (Genova, Italy); TRI: Lionello Tringali (Roma, Italy); VAZ: Angelo Vazzana (Reggio Calabria, Italy); VIL: Alberto Villari (Messina, Italy). sh: empty shells; WI: wrong identification; H: height; W: width; DS: standard deviation.

RESULTS

Systematics

(Citation of unpublished names is not intended for taxonomic purposes)

Classis GASTROPODA Cuvier, 1795
Subclassis CAENOGASTROPODA Cox, 1960
Ordo NEOGASTROPODA Wenz, 1938
Superfamilia CONOIDEA J. Fleming, 1822
Familia RAPHITOMIDAE Bellardi, 1875

Genus *Raphitoma* Bellardi, 1847. Type species: *Pleurotoma hystrix* Cristofori and Jan, 1832 (nomen nudum, validated by Bellardi (1847) as "*Pleurotoma histrix* Jan.") by subsequent designation (Monterosato, 1872: 54).

Cordieria Monterosato, 1884 non Roualt, 1848. Type species: *Murex reticulatus* Brocchi, 1814, by subsequent designation (Crosse, 1885).

Philbertia Monterosato, 1884.Type species: *Pleurotoma philberti* Michaud, 1829 by subsequent designation (Crosse, 1885).

Cyrtoides F. Nordsieck, 1968. Type species: *Pleurotoma rudis* Scacchi, 1836, by original designation.

Raphitoma densa (Monterosato, 1884) [*Philbertia*]
Nomenclatura generica e specifica: 133 - Figs. 1–19, 23–24, 31

Pleurotoma versicolor var. *cinereomaculata* Scacchi, 1836: 13 (nomen nudum)
Philbertia densa Monterosato, 1884: 133
Clathurella decorata pars Locard, 1891: 67 (lectotype selected herein)
Clathurella bucquoyi pars Locard, 1891 not Locard, 1886
Philbertia densa Carus, 1893: 425
Philbertia densa Pallary, 1900: 256
Philbertia purpurea var. *densa* Pallary, 1912: 83
Clathurella densa Hidalgo, 1917: 247
Philbertia densa Monterosato, 1917: 25
Raphitoma philberti densa Nordsieck, 1968: 177
Raphitoma philberti var. *densa* Parenzan, 1970: 212
Raphitoma (*Ph.*) *flavida* Nordsieck, 1977: 54, pl. 17 n. 132 (lectotype selected herein)
Raphitoma (*Philbertia*) *bourguignati tarentina* Nordsieck, 1977: 55 pl. 17 n. 136
Raphitoma (*Philbertia*) *densa* Piani, 1980: 157
Philbertia densa Sabelli et al., 1990: 45, 217
Raphitoma bicolor sensu Poppe & Goto, 1991 non Risso, 1826: pl. 35 n. 20
Raphitoma densa Cachia et al., 1993: 34
Raphitoma (*Philbertia*) *densa* Delamotte & Vardala-Theodoru, 1994: 287
Philbertia densa Arduino et al., 1995: 95 (figured)
Raphitoma densa Cachia et al., 2001: 65 pl. 10 fig. 1 (WI = *R. lineolata*)
Raphitoma densa Cretella et. al., 2005: 121
Raphitoma densa Repetto et al., 2005: 217 n. 893 (figured)
Raphitoma densa Trono, 2006: 68
Raphitoma contigua Monterosato, sensu Cossignani & Ardovini, 2011: 325
Raphitoma densa Cossignani & Ardovini, 2011: 325 (only fig. a)
Raphitoma densa Repetto et al., 2011: 41,135
Raphitoma densa Manousis, 2012: 178 (figured)
Raphitoma densa Trono & Macrì, 2013: 35
Raphitoma densa Scaperrotta et al., 2018: 21, 78 (figured) *Raphitoma densa* Manousis et al., 2018: 10, figs. 7 b-h

ORIGINAL DIAGNOSIS (Monterosato, 1884). "P. densa, *Monts. (nov. Forma)* = Pl. versicolor, *var.* cinereo maculata, *Sc. ex typo (Nap.). Reticolazione fitta, colorito fosco a macchie dense cineree o cerulee. Cette (Maltzan f. Verkruzen); Corsica (Nevill); Livorno (Caifassi); Civitavecchia (Del Prete); Malta (Medlycott); Alessandria (Gaudion); Falera (Morlet); Palermo e Trapani (Monts.)*".

TYPE LOCALITY. Palermo

EXAMINED MATERIAL. The type material and:
Atlantic. Portugal - Algarve, 1 sh (MNHN), 2 sh (SMNH lot 73393c); Ponta da Baleeira, Sagres, Algarve, 2 sh (SMNH lot 73393c).
Mediterranean. unprecised locality, 2 sh (SMNH lot 73180). Alboran Sea, 3 sh (OLI).
Spain - Algeciras, 1 sh (CRO); Fuengirola, 1 sh (SMNH lot 73169); Malaga, 1 sh (RUF), 1 sh (AHU); Punta de la Mona, 2 sh (BAR); Cabo de Gata Los Escullios, 1 sh (CRO); Getares, 1 sh (PAG); Baleares Isl., 1 sh (MNHN Paris, ex coll. de Brieux); Barcelona, - 40 m, 1 sh (PAO).
France. Provence, 2 sh (MCZR-M-16807); Roussillon, 2 sh (MCZR-M-16807); Bandol, Var, 1 sh (MCZR-M-16807); S. Raphael, 2 sh (MNHN coll. Locard), 2 sh (MNHN coll. Couturier sub nomine *Cl. corbiformis*), 11 sh (MCZR-M-16807), 2 sh (MCZR-M-16794), 1 sh (HUJ coll. Coen lot 1914A sub nomine *Philbertia purpurea bicolor*, with Coen label), 1 sh (MCZR-M-16785) sub nomine ms. *acutalis*; Embiez Isl., Provence, 10 sh (MNHN); Provence, legit Claudio Ebreo 1 sh (PUS). Corse. Baie de Calvi, 2 sh (SMNH lot 73171F), 1 sh (SMNH lot 73172A), 1 sh (PUS); Ile Rousse, >10 sh (BAR); Ajaccio, 1 sh (CRO).
Italy. Capo Noli, Savona, 1 sh (RUF); Laconella, Elba Isl., -6 m, 2 sh (CRO); Capraia Isl., 1 sh (BAR); Giannutri Isl., 3 sh (SMR), 1 sh (BAR); Punta Ala, Grosseto, 10 sh (BAR); Antignano, -8 m, 1 sh (PAO); Golfo di Baratti, -10 m, 3 sh (PAO); Baratti, Livorno, 1 sh (PAG); 1 sh. (PAG); Castiglioncello, Livorno, 4 sh (MAR), 2 sh (PAO), 3 sh (PAG), 1 sh (MCZR-M-16807); Punta Ala (Grosseto), 2 sh (GER), 2 sh (PAG); Talamone (Grosseto), 6 sh (RUF); Secca delle Vedove, Livorno, 3 sh, -100/130 (PAO); Latium, 1 sh (GIR); Ladispoli, Latina, 1 sh (DES); S. Agostino, Gaeta, Latina, 1 sh (CRO); Capri Isl., 2 sh (HUJ, coll. Coen lot 9473B, sub nomine "*Philbertia purpurea prolixa* ms", ex coll. Bellini), 1 sh (MCZR-M-16807), 1 sh (CRO); Procida Isl., 1 sh (MAR), 3 sh (CRO); Napoli, 2 sh (HUJ coll. Coen, lotto 9473. A sub nomine *Philbertia purpurea prolixa* ms), 1 sh (MCZR-M-16788), 1 sh (SMNH lot

70492A), 4 sh, (MCZR-M-16807; Bacoli Punta Pennata, 1 sh (CRO); Marina di Puolo, Napoli, 1 sh (DUR); Punta Pioppeto (Ischia Isl.), 1 sh (PUS), 1 sh. (PAG), 4 sh (CRO); Sapri, Salerno, 1 sh (CAR); Secca di Pellaro, Reggio Calabria, 1 sh (PAO); Scilla, Reggio Calabria, 15 sh (VAZ); Taranto, 2 sh (MCZR-M-16813 sub nomine ms. "*specialis*"), 2 sh (MCZR-M-16807); Otranto, Lecce, 1 sh (MAC); Torre Serpe, Otranto, Lecce, 2 sh (MAC); Novaglie, Lecce, 1 sh (MAC); San Cataldo, Lecce, -6 m, 2 sh (CRO); Marina di Ugento, Lecce, 2 sh (MAC); Nardò, Lecce, 1 sh (COL); Porto Cesareo, Lecce, 2 sh (CRO), 6 sh (FIO); Cala Rena, Giovinazzo, Bari, 1 sh (MEL); Giovinazzo, Bari, 12 sh (MEL).

Sardinia. Castelsardo, Sassari, (BAR); Secca di Castelsardo, -40, 3 sh (BAR); Aranci Gulf, 1 (NOF); Arzachena, Sassari, 1 sh (DON); Porto S. Paolo, Sassari, 1 sh (DON); Punta Marana, Sassari, 1 sh (TRI); Stintino, Sassari, 1 sh (RUF); S'Archittu, Oristano, 24 sh (SOS); Cagliari, 2 sh (PIS); Poetto, Cagliari, 2 sh (PIS); Sant'Antioco, Carbonia-Iglesias, 10 sh (PIS); Calasetta, Carbonia-Iglesias, 1 sh (PIS).

Sicily. S. Raineri, Messina, 1 sh (MCZR-M-16877); Pace, Messina, 1 sh (VIL); Ficarazzi, Palermo, 7 sh (PUS); Isola delle Femmine, Palermo, 4 sh (PUS legit Bagnera), 11 sh (SER); Ustica Isl., 3 sh (VIL); Palermo, 3 sh (HUJ coll. Coen, Hebrew Univ. sub nomine *Philbertia purpurea bicolor*, lot 1914B), 2 sh (HUJ lot 8071 with Monterosato's label "*Philbertia densa*", 2 sh MCZR-M-16806 sub nomine *Philbertia atropurpurea* var. minor), 7 sh (PUS); Trapani, 1 sh (SER), sh (MCZR-M-16807); S. Giuliano, Trapani, 5 sh (PAL); Acitrezza, Catania, 1 sh (SMNH lot 73198E); Cannizzaro, Catania, 1 sh (PAG); S. Giovanni Li Cuti, Catania, 1 sh (VIL); Brucoli, Siracusa, 1 sh (SMNH lot 73206C), 3 sh (PUS); Porto Palo, Siracusa, 1 sh (PAL), 3 sh (GER); Pozzallo, Ragusa, 1 sh (MRSNT lot 18280 sub nomine *R. reticulata*); Pozzallo Porto, Ragusa, 1 sh (CRO); Capo Passero, Ragusa, 1 sh (MAR); Lampedusa Isl., 1 sh (PAG).

Croatia. Krk Island, 14 sh (BAR).

Tunisie. Djerba Island, 1 sh (PUS); Gulf of Gabes, 5 sh (SMNH, lot 73177G).

Greece. Kalymnos Island, 1 sh (RAV); Simi Island, 1 sh (SMNH lot 25329a); Malia, Crete, 1 sh (CRO); Pefko, Skiros Isl., -6 m, 4 sh (CRO); Plataria, Igoumenitsa, -6 m, 3 sh (CRO).

Turkey. Bozcaada Island, 1 sh (PUS).

Egypt. Alexandria, 1 sh (PUS).

DESCRIPTION. In square brackets the data of the holotype. Shell fusiform, of medium size for the genus, height 8-16.4 mm, mean: 11.18 DS: 2.1 [11.7]; width 3–6 mm, mean: 4.24 DS: 0.69 [4.6]; H/W 2.32–2.86, mean: 2.63 DS: 0.16 [2.54].

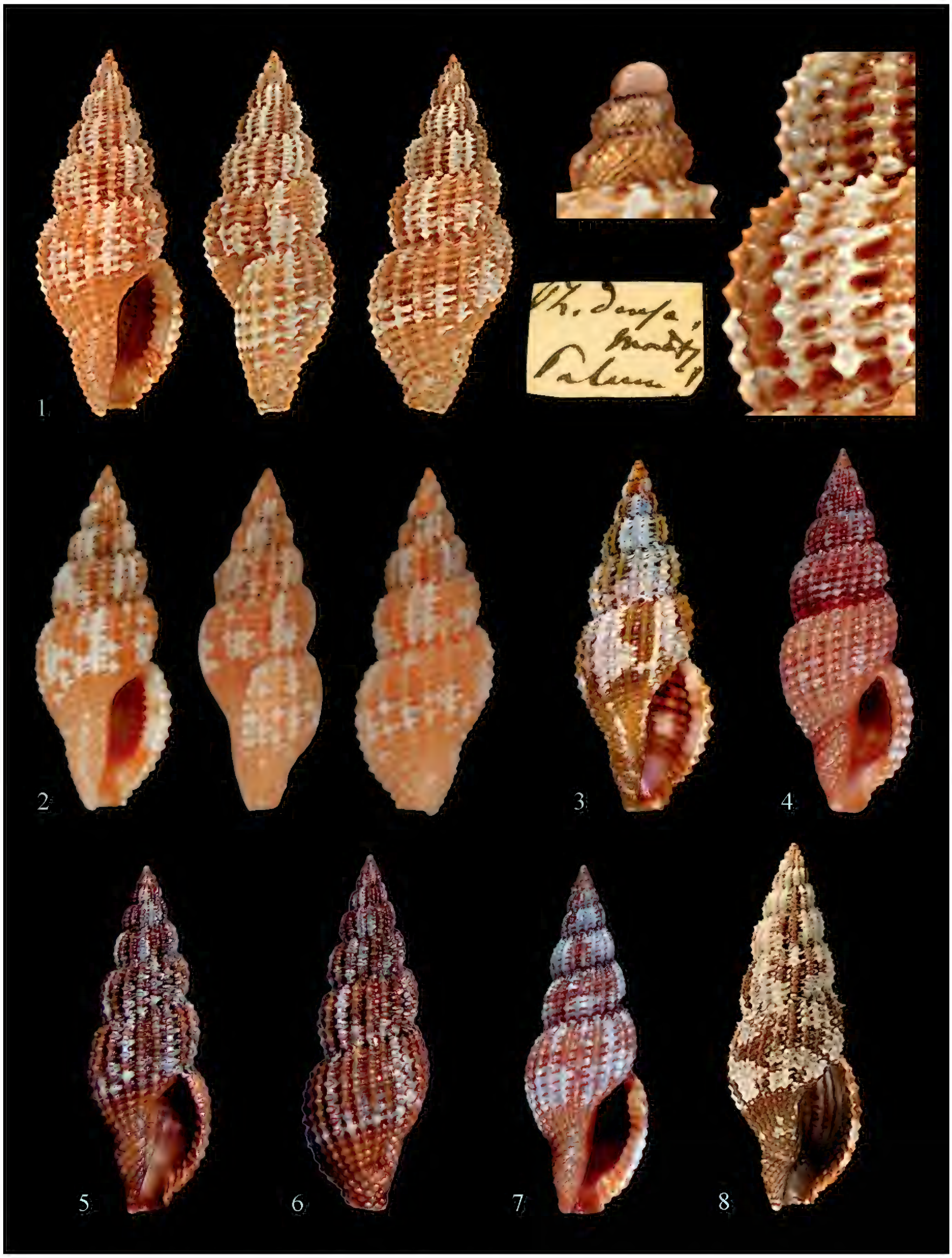
Protoconch multispiral of 3 convex whorls, heigth 458 µm, width 415 µm, protoconch I of 1 whorls, width 235 µm, covered by thin cancellations, protoconch II with a diagonally cancellated sculpture starting after a zone under the suture with fine axial threads. The last whorl show a short keel before the onset of the teleoconch. Protoconch-teleoconch boundary slightly flexuose, opisthocline.

Teleoconch of 7–9 [7] convex whorls, slender and stout, suture incised, sculpture robust. Densely disseminated microgranules in the surface. Axial sculpture of 16–29 mean 21 DS 3.5 [21] orthocline, equidistant ribs, and interspaces slightly narrower than the ribs. Spiral sculpture of 6–9 mean 7 DS 0.91 [7] cordlets above the aperture. Cancellation rectangular, with strong and sligthly acute tubercles at the intersection of axials and spirals. Subsutural ramp narrow, with small tubercles in correspondence with the axial ribs tip and one or two small spiral cordlets.

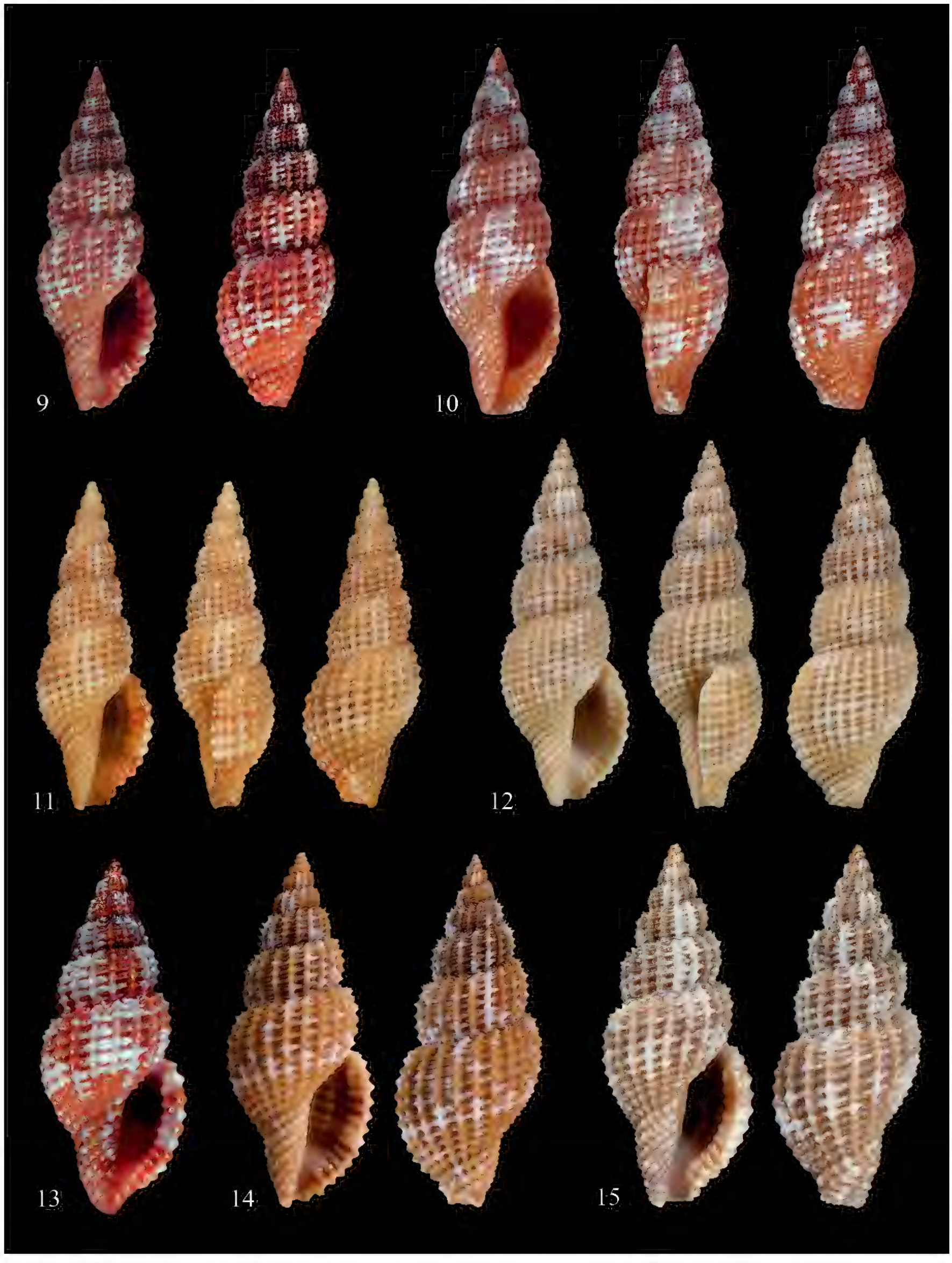
Columella simple, slightly sinuous anteriorly, gently angled posteriorly. Siphonal channel short. Outer lip with 10–14 mean 11 DS 1.38 [11] strong inner lyrate denticles, the most posterior is shorter. Siphonal fasciole with 6–10 strong nodulose cords [8] mean 8 DS 0.89.

Colour uniformly orange brown in the background (from ligth to dark), with large ashy blotches, as wide as 1–3 axial ribs. Suprasutural cordlet (rarely two) at least on the last whorl. Comma-shaped ashy spots on the subsutural ramp. Enterely white specimens are known. Soft parts unknown.

DISTRIBUTION AND BIOLOGY. The entire Mediterranean, Canary Islands (Tenerife). In the Mediterranean Sea, species of *Raphitoma* are usually active at night time, and live mostly on soft bottoms, 0–100 m depth, ranging from coastal bioclastic coarse sands to muddy bioclastic coarse sands, but also in sandy pockets amidst rocks or phanerogams meadows, although it is not infrequent to find specimens hiding under stones and in crevices, especially at daytime. One species (*R. pseudohystrix*) has been found in bottoms down to 700 m depth.



Figures 1–8. Shells of *Raphitoma densa*. Fig. 1: Lectotype, Palermo, Italy (MCZR-M 16807), h: 11.7 mm; Fig. 2: Trapani (Italy), h: 11 mm; Fig. 3: Torre Astura, Latina (Italy), h: 12 mm; Fig. 4: Toulon (France), h: 13.2 mm; Fig. 5: Ladispoli (Roma), h: 10 mm; Fig. 6: Ladispoli, Roma (Italy), h: 11 mm; Fig. 7: St. Raphael (France), h: 9.9 mm; Fig. 8: Castiglioncello (Livorno), h: 11.8 mm.



Figures 9–15. Shells of *Raphitoma densa*. Fig. 9: Posillipo (Italy), h: 12.8 mm; Fig. 10: St. Raphael (France), h: 13.1; Fig. 11: Palermo (Italy), h: 10.4 mm; Fig. 12: Napoli (Italy), h: 16.2; Fig. 13: Golfo di Baratti (Italy), h: 8.1 mm; Fig. 14: St. Raphael (France), h: 8.5 mm; Fig. 15: Brucoli, Siracusa (Italy), h: 10.5 mm.

Figure 16. *Clathurella decorata*. Lectotype, St. Raphael (France), h: 12.7 mm; Figure 17. *Clathurella bucquoyi* Locard, 1891. Paralectotype, Ajaccio, Corse (France), h: 8 mm; Figure 18. *Raphitoma* (*Philbertia) bourguignati tarentina*. Holotype, Taranto (Italy), h: 9.7 mm; Figure 19. *R. (Ph.) flavida*. Lectotype, Ibiza Isl. (Spain), h: 7.4 mm; Figure 20. *R. lineolata*, Saronic Gulf (Greece), h: 7 mm; Figure 21. *R. corbis*, Termini Imerese, Palermo (Italy), h: 10.3 mm; Figure 22. *R. corbis*, Isola delle Femmine, h: 10.5 mm

REMARKS. Scacchi (1836: 13) described *Pleurotoma versicolor.* The type material seem to be lost (Nicola Maio, pers. comm. and Cretella et al., 2004: 123), but from the original description seems that more than one species are involved, i.e., *R. philberti, R. bicolor* and *R. densa.* Moreover the additional *P. versicolor* var. *cinereo-maculata* Scacchi, 1836 is a nomen nudum.

Locard (1891: 67) introduced *Clathurella decorata*. In the Locard collection at MNHN Paris we found 3 lots of this species. One contain 2 specimens from Marseille that are related to *R. atropurpurea* (Locard & Caziot, 1899), one contain 2 specimes from Toulon also related to *R. atropurpurea* and a third one containing 4 specimens from St. Raphael related to *R. densa* (Monterosato, 1884). To maintain the nomenclatural stability we designed from this last lot as lectotype a specimen of mm 12.7 x 4.8. So *C. decorata* Locard, 1891 become a synonym of *Philbertia densa* Monterosato, 1884 that take precedence (Fig. 16).

Locard (1886) introduced *C. bucquoyi* (a name available by indication (I.C.Z.N., 1985: Art. 12.2.1). To stabilize the use of this name we designate (Gi-

annuzzi Savelli et al., 2018: 19) the specimen from Saint Lunaire figured by B.D.D. (1883: figs. 13, 14; as "*Clathurella purpurea* var. *philberti* Michaud"), a typical *R. oblonga.*

Only subsequently did Locard (1891) provide an extensive description of *C. bucquoyi*, reporting it as common in the Mediterranean, but unfortunately mixing it with other species of the *R. bicolor* group (not identifiable as lacking protoconch), including *R. densa.*

So we assume that there are two *C. bucquoyi*, one from 1886 and one from 1891.

Among the type material from *C. bucquoyi*, there are two paralectotype from Ajaccio and three from St. Raphael, all related to *R. densa* (Fig. 17).

Nordsieck (1977: 55 pl. 17 n. 136) introduced *Raphitoma* (*Philbertia*) *bourguignati tarentina*. The type material in SMF consists in the holotype from Taranto, mm 9.7 x 3.6 ed a paratype (mm 10.5 x 3.9) labelled "Cataldo, Adria" [probably San Cataldo, Lecce, Adriatico]. The holotype is clearly a specimen of *R. densa* and the paratype is related to *R. atropurpurea* (Fig. 18).

Again, Nordsieck (1977: 54, pl. 17 n. 132) introduced *Raphitoma* (*Ph.*) *flavida* Monterosato, 1884. Unfortunately, Monterosato never described a species with this name. Monterosato (1875: 55) introduced a *Pleurotoma* (*Defrancia*) *purpurea* var. *flavida*, but this is a nomen nudum. Again, Monterosato (1878: 106) introduced *Pleurotoma corbis* var. *flavida*, but this too is a nomen nudum.

So the name *Raphitoma flavida* should be credited to Nordsieck, 1977 that also give a description.

The type material consist in 3 lots. One from Ibiza (SMF lot 337099/28 with original manuscript label Philb. *purp. flavida* Mts/Ibiza) containing 12 shells and 1 fragment. Ten shells and the fragment are referable to *R. densa*, of the other two (both with traces of multispiral protoconchs), one is not identifiable and the other seem to be a juvenile of *R. corbis*. One (SMF lot 337100/1) with original ms label "*Philbertia flavida* Mts/ S' Pol de Mar" contain 1 shell referable again to *R. densa*. A third one SMF lot 337101/1 with original ms label "*Philb. flavida* Mts/Sfax" contain 1 shell still referable to *R. densa.*

Then we designate as lectotype a specimen from lot 337099/28 coming from Ibiza, mm 7.4 x 3.0 with incomplete peristome (Fig. 19).

Thus, *R. flavida* Nordsieck, 1977 becomes a junior synonym of *R. densa.*

Raphitoma densa differs from *R. lineolata* (B.D.D., 1883) (Fig. 20) for to the lack of the characteristic brown spirals on the background and for the ashy blotches vs. whitish on the background.

From *R. corbis* (Potiez et Michaud, 1838) (Figs. 21, 22) it differs for its characteristic ashy blotches and for less evident sculpture.

Raphitoma griseomaculata Pusateri et Giannuzzi-Savelli n. sp. - Figs. 23–26, 32

Raphitoma cfr. *alternans* Manousis et al., 2018: 5; fig. 3 c

TYPE MATERIAL. Holotype mm 13.9 x 5.5 and paratype A mm 10.6 x 4.4 (MNHN), paratype B mm 11.6 x 4.6 (PUS), paratype C mm 10.1 x 4.2 (FIO) all from type locality (legit A. Fiorita & M. Perini).

TYPE LOCALITY. 1 mile off Torre Squillace, Porto Cesareo (Lecce) -20/30 m 40°13'N - 17°50'E

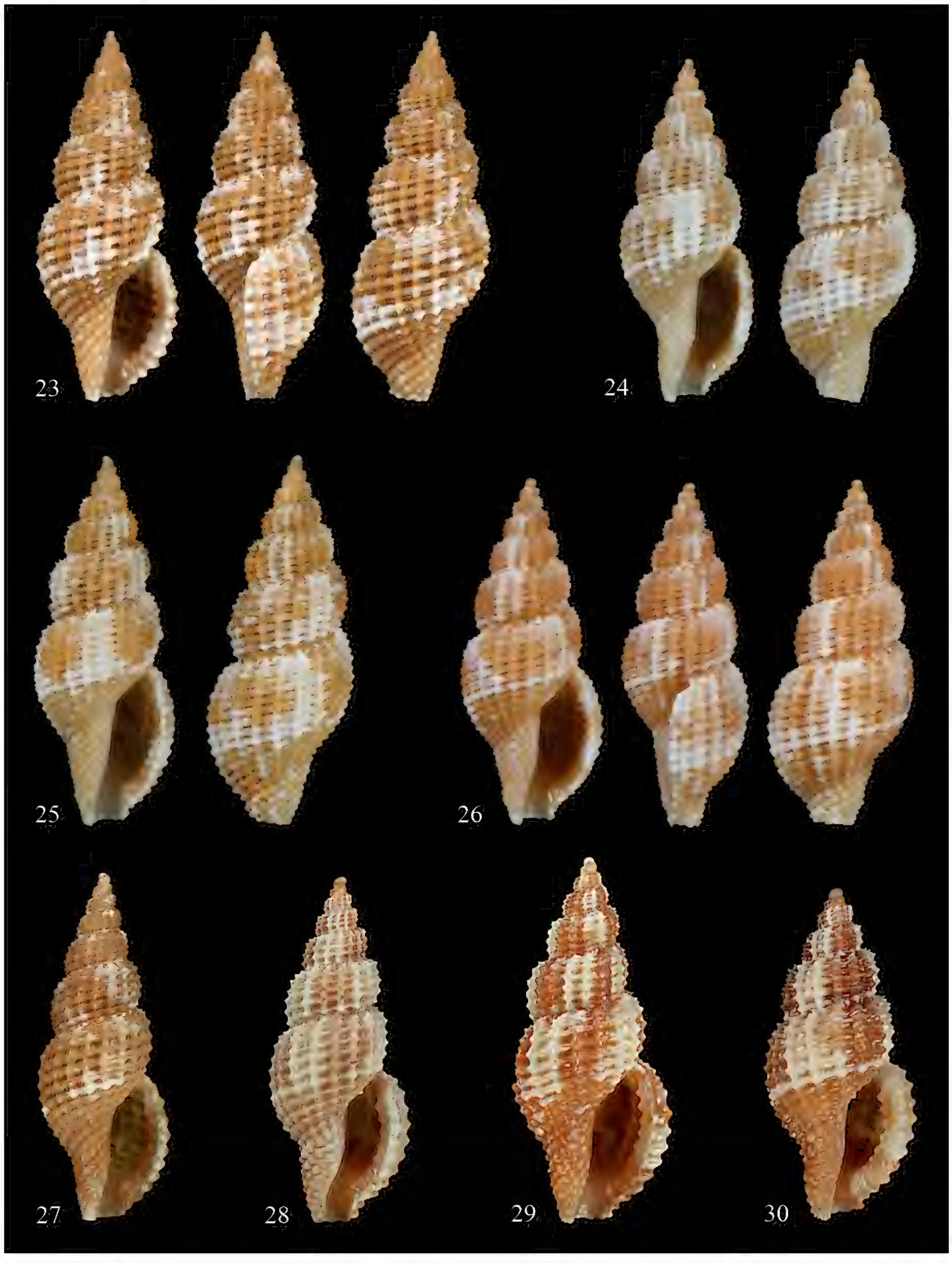
EXAMINED MATERIAL. Only the type material.

DESCRIPTION OF THE HOLOTYPE. Shell slender fusiform, of medium size for the genus, height: 13.9 mm, width: 4.7 mm. H/W: 2.53 mm.

Protoconch paucispiral (Fig. 32). Only protoconch I of 0.9 convex whorls, height: 230 µm, width: 225 µm; sculpture with horizontally elongated rectangles. In the last part there are fine curved axial threads in the subsutural zone. Protoconch-teleoconch boundary indistinct but flexuose.

Teleoconch of 6 convex whorls, solid, suture evident, medium-strength sculpture. No microgranules on the surface. Axial sculpture of 20 slightly opisthocline, equidistant, robust ribs, and interspaces 1.1 as wide as the ribs. Spiral sculpture of 8 cordlets above the aperture, narrower than the axials. Cancellation rectangular, with strong and slightly elongated (acute in the first whorls) tubercles at the intersections.

Subsutural ramp very short. Columella simple, slightly sinuous anteriorly, gently angled posteriorly. Outer lip with 11 elongated inner denticles, the most anterior delimiting the short and wide siphonal canal is smaller than other, the most posterior delimiting the shallow anal sinus is smaller than the others. Siphonal fasciole with 9 nodulose cords.



Figures 23–26. Shells of *Raphitoma griseomaculata* n. sp. Torre Squillace, Porto Cesareo, Lecce (Italy). Holotype, h: 13.9 mm; paratype A, h: 10.6 mm; paratype B: h: 11.6 mm; paratype C: h: 10.1 mm. Figure 27. *R. smriglioi*, holotype, Ognina, Siracusa (Italy), h: 9.4 mm. Figure 28. *R. philberti*, Palermo (Italy), h: 8.5 mm. Figure 29. *R. papillosa*, Djerba Isl. (Tunisia), h: 9.7 mm. Figure 30. *Raphitoma farolita*, Cannizzaro, Catania (Italy), h: 7.5 mm.

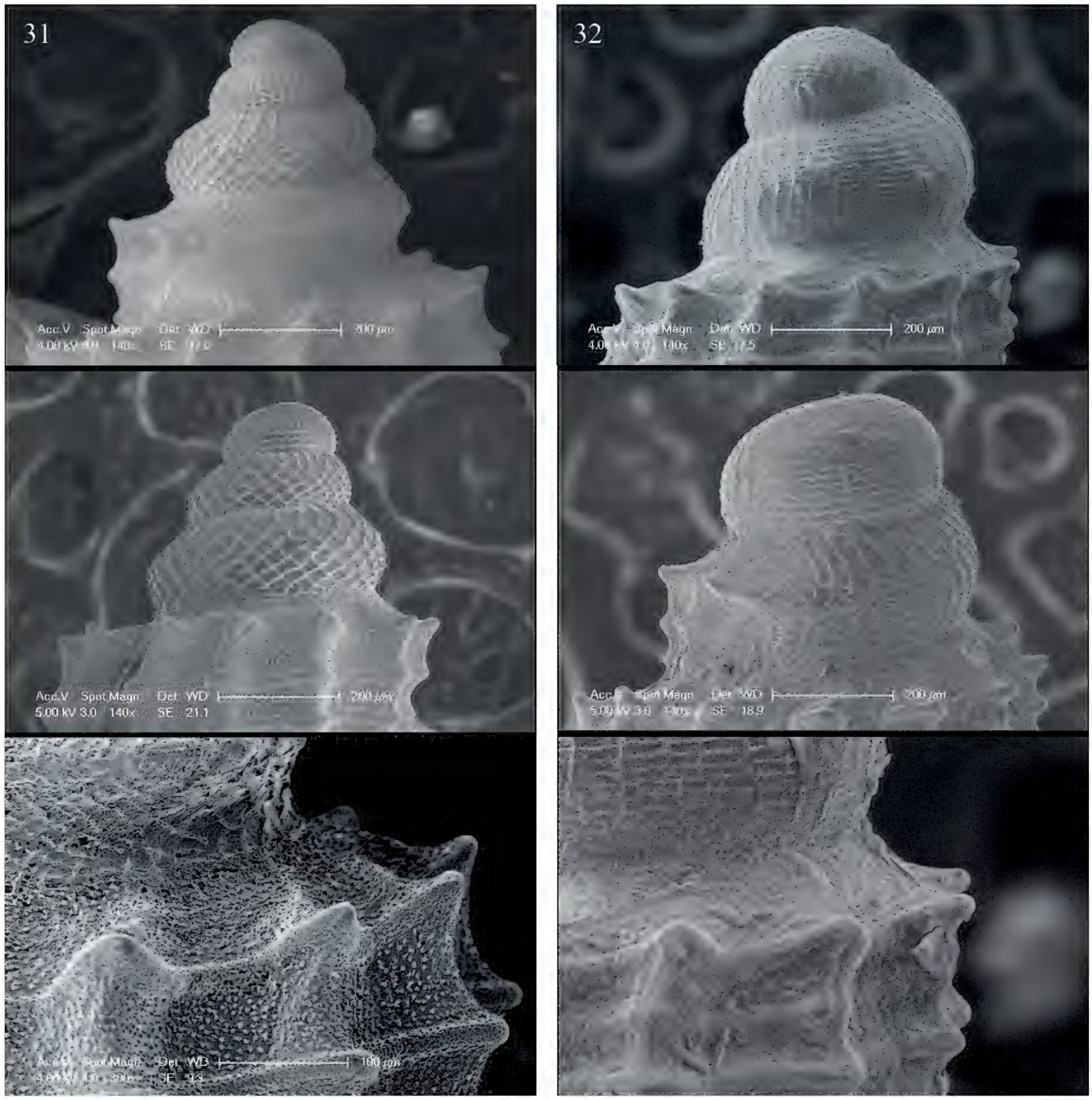

31
32
Acc.V Spot Magn Det WD 200 µm
5.00 kV 3.0 140x SE 21.1
Acc.V Spot Magn Det WD 200 µm
5.00 kV 3.0 140x SE 18.9
Acc.V Spot Magn Det WD 100 µm
5.00 kV 3.0 300x SE 9.3

Figure 31. *Raphitoma densa*, protoconch. Figure 32. *Raphitoma griseomaculata* n. sp., protoconch.

Colour uniformly straw yellow (the background, with ashy blotches). Suprasutural cordlet same colour as the blotches, at least on the last whorl.

Soft parts unknown.

VARIABILITY. The paratypes have: height: 10–14 mm, width: 4.2–5.5 mm, H/W: 2.38–2.53. Teleoconch of 7–8 convex whorls. Axial sculpture of 20–24 ribs, and interspaces from 1 to 1.5 as wide as the ribs. Spiral sculpture of 8–10 cordlets above the aperture. Sometime one supplementar secondary cordlet can occur. Outer lip with 11–14 elongated inner denticles. Siphonal fasciole with 9–10 nodulose cords. Colour uniformly straw yellow to yellow orange.

ETYMOLOGY. A compound noun derived from the latin words "*griseus*" = gray, and "*maculatus*" = spotted, speckled.

DISTRIBUTION. This species is only known due to the type locality: Torre Squillace, Porto Cesareo (Lecce, Italy).

REMARKS. *R. griseomaculata* n. sp. differs from *R. smriglioi* Pusateri et Giannuzzi-Savelli, 2013 having a different protoconchs (more regular profile vs. semi-strangled upper outline and a slight keel in the low part) for to the lack of the characteristic brown spirals of the background and the color (paler in *R. griseomaculata* n. sp. and more saturated in the *R. smriglioi*).

The new species differs from the light *R. philberti* (Michaud, 1829) having his blotches neat and not vanishing, the outline less slender and the lacking of one subsutural ramp.

Raphitoma papillosa (Pallary, 1904) have a more strong sculpture and the blotches are not ashy grey.

Raphitoma farolita (Nordsieck, 1977) is much more robust and less slender (HD: 2.15–2.24 vs. 2.38–2.53) than *R. griseomaculata* and blotches are pure white.

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About the presence of the wood mouse *Apodemus sylvaticus* (Linnaeus, 1758) (Mammalia Rodentia Muridae) in a rocky habitat in the central Apennines (Italy)

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ABSTRACT In this paper, some data about the presence of *Apodemus sylvaticus* (Linnaeus, 1758) (Mammalia Rodentia Muridae) in rocky environments of the National Park of the Sibillini Mountains are provided. Considering the available data on the distribution of *A. sylvaticus* in Italy, this appears to be an unusual finding, which can be explained considering the strong reduction that the preferred environment by this species, the wooded areas, has suffered in the past by man and possible competitions with other forest rodents.

KEY WORDS *Apodemus*; ecology; Sibillini; Marche; Italy.

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INTRODUCTION

The wood mouse, *Apodemus sylvaticus* (Linnaeus, 1758) (Mammalia Rodentia Muridae), is a rodent distributed throughout Europe (with the exception of Finland and northern parts of Scandinavia, the Baltic and Russia) and parts of North Africa (Schlitter et al., 2016).

In Italy, it is present throughout the territory, including Sicily and Sardinia (Capizzi & Filippucci, 2008), and on some small islands such as Pantelleria, Favignana, Marettimo, Ischia, Vivara, Montecristo, Giglio, Elba, Asinara, Caprera, La Maddalena and Spargi (Angelici et al., 2009).

In peninsular Italy, the distinction on the morphological basis with the congeneric *A. flavicollis* (Melchior, 1834), is often difficult even if, the two species, are separated from the genetic point of view (Witte, 1964; Niethammer, 1969; Recco et al., 1978; Nascetti et al., 1980; Gemmeke, 1980; Contoli et al., 1984).

With regard to environmental presences, in the atlas of European mammals (Montgomery, 1999), it is reported as a species present in woodlands of all kinds, moors, riparian habitats, agricultural land, forestry plantations, suburban but also urban areas if parkland or railway embankments are available; particularly, the western populations are associated with several habitats, the eastern ones are common in woodland edge habitats and the most extreme

populations live in the steppeland. Finally, it is one of the most common small mammals found in the more arid Mediterranean habitats.

In his work on Italian rodents, Santini (1983) reports *A. sylvaticus* as a very adaptable species, which can be found in any biotope with herbaceous vegetation and some shrubs.

In the recent review on Erinaceomorpha, Soricomorpha, Lagomorpha and Rodentia of the "Fauna d'Italia" series (Capizzi & Filippucci, 2008), it is reported as a predominantly forest species but able to live in other environments such as hedges, uncultivated and cultivated fields, parks and gardens.

In this paper, some data about the presence of *A. sylvaticus* in rocky environments of the National Park of the Sibillini Mountains are provided.

The National Park of the Sibillini Mountains, established in 1993, extends for little less than 70,000 hectares in the territory of two regions (Marche and Umbria, central Italy). The mountainous chain giving its name to the protected area is purely calcareous, spreading for about 30 km and it was deeply modeled by the action of glaciers during Quaternary, whose traces are still recognizable in the beautiful glacial cirques of the Mount Vettore (2,476 m), of the Mount Sibilla (2,173 m) and of the Mount Bove (2,169 m), where human presence has always been limited.

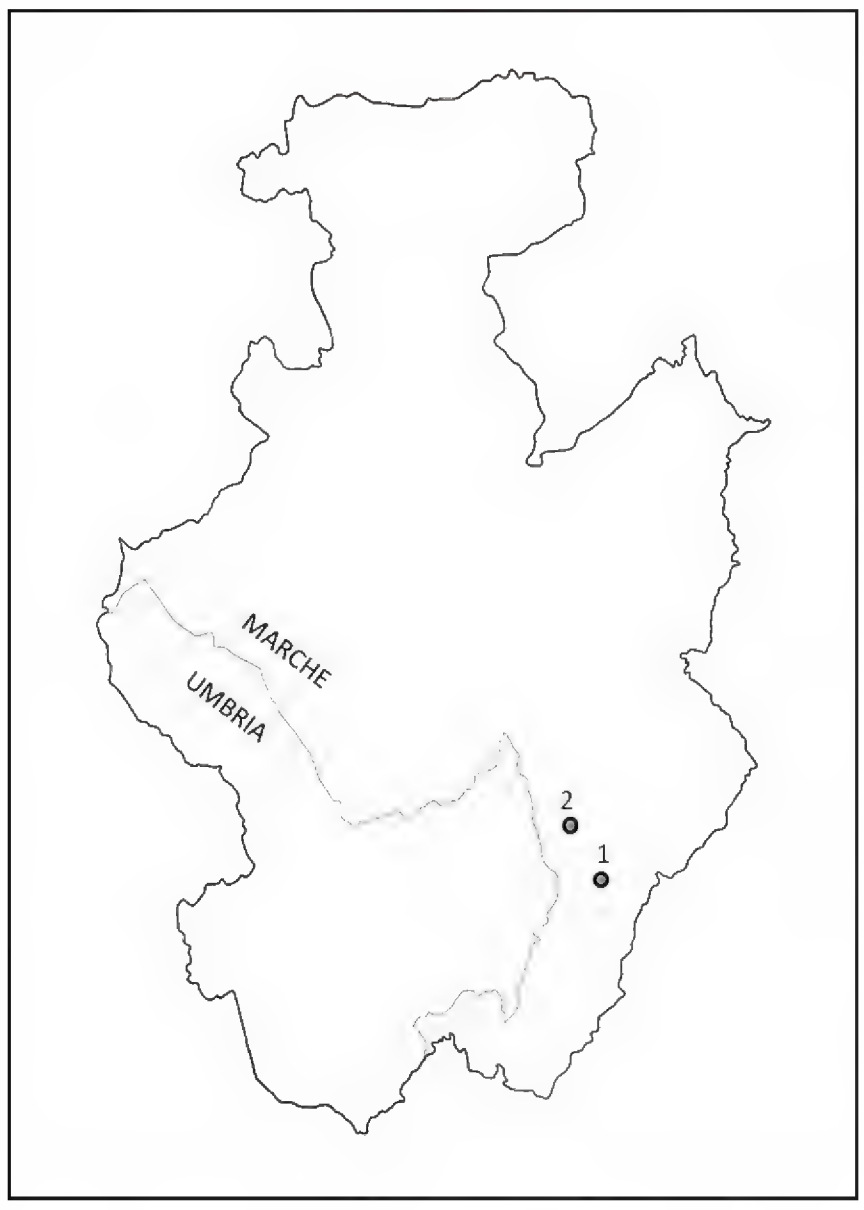

Figure 1. The perimeter of the National Park of the Sibillini Mountains and the localities considered in our research. 1: Rifugio Zilioli, 2: Pizzo del Diavolo eastern side.

Descending from the main axis of the Apennine ridge, an eastern slope characterized by narrow valleys oriented northwards and a western slope in which it can find typical depressions of the high altitudes: the karst phenomena are particularly evident in the plains of Castelluccio di Norcia and in the numerous sink-holes, tracks and cavities to be found along the main valleys.

The hill areas, mostly marly-arenaceous, are more anthropized, as well as the valley floors: specialized farming and small industrial areas, arisen next to the most populated towns, characterize the legal borders of the Park.

From the main ridge, representing the watershed between the Tyrrhenian and the Adriatic sides, many inaccessible and wild valleys degrade, crossed by rivers and torrents such as Rio Sacro, Fiastrone, Ambro, Tenna, Aso, Fluvione on the Adriatic side, Nera and Ussita on the Tyrrhenian side. The northern and southern borders of the Park are individuated by Chienti and Tronto rivers respectively.

In the territory of the protected area lake basins are also present: the Lake Fiastrone, created in 1,955 for hydroelectric purposes, and the Lake Pilato, small cirque basin located at 1,941 m asl, the only natural lake in the Marche region.

From the botanical point of view the Park, registering more than 1,800 floral species, is characterized by extended secondary meadow pastures, by downy oak woods (hill plain), by mixed deciduous forest and residual beechwood strips, undergoing forestry practices (mountain plain) over 1,800 m a.s.l., even though reduced in comparison to the past, where primary grasslands develop (Pedrotti, 2002).

It is necessary to mention how during the centuries the human activities traditionally linked to animal farming have caused a relevant reduction of the forest environment, favouring secondary mountain grasslands. By the way, these grasslands have become important ecosystems, protected also at an EU level, because of their richness in rare or en-

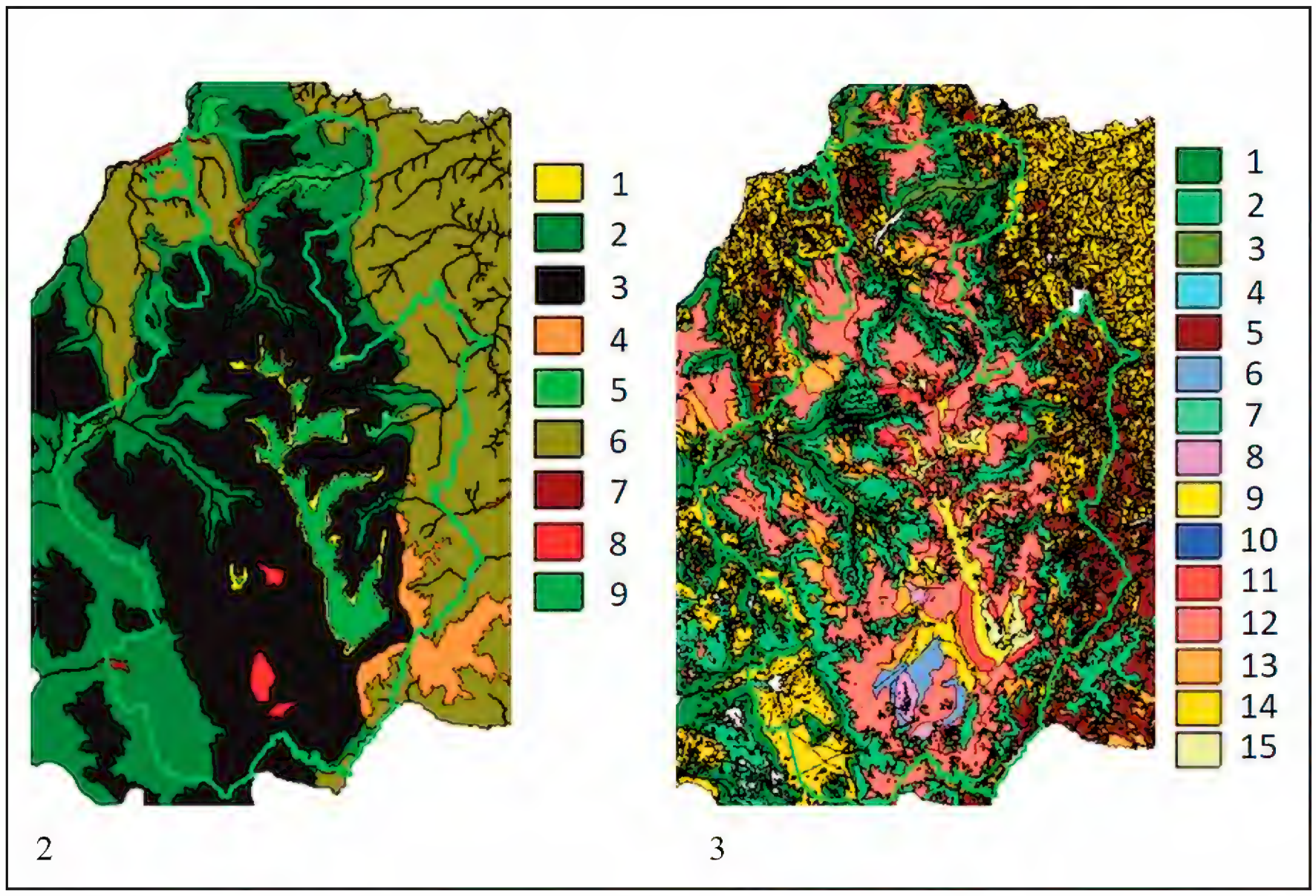

Figure 2. Potential vegetation of the National Park of the Sibillini Mountains and surrouding areas (from www.sibillini.net/il_parco/index.php). 1: subalpine shrubs (*Prunetaliae*); 2: European hop-hornbeam forests (*Quercetalia pubescentis*, *Laburno-Ostryon*); 3: beech forests on calcareous substrate (*Fagetalia sylvaticae*); 4: beech forests on marly-arenaceous substrate (*Fagetalia sylvaticae*); 5: evergreen oak forests (*Quercetalia illicis*); 6: downi oak and locally Turkey oak forests (*Quercetalia pubescentis*, *Quercion pubescentis*); 7: riparial forests (*Salicetalia purpureae*, *Populetalia albae*); 8: marshy meadows (*Magnocarioetalia*); 9: primary meadows (*Seslerietalia apenninae*).

Figure 3. Real vegetation of the National Park of the Sibillini Mountains and surrouding areas (from www.sibillini.net/il_parco/index.php). 1: European hop-hornbeam and manna ash forests; 2: beech forests; 3: evergreen oak forests; 4: riparial forests; 5: downi oak and locally Turkey oak forests; 6: mowing grassland; 7: hygrophile meadows; 8: met grass meadows; 9: primary meadows; 10: marshy meadows; 11: secondary open meadows; 12: secondary sluice meadows; 13: abandoned fields; cultivated fields.

demic floral species and as a fundamental habitat for several animal species.

Fauna is also relatively diversified; about 200 vertebrate species are esteemed, even though there is still little information about the real size and chorology of small mammals and bats' populations (Fermanelli, 2002; Fiacchini & Rossetti, 2013). In 2008, the Apennine chamois (*Rupicapra pyrenaica ornata* Neumann, 1899) has been successfully introduced, in the wild, thanks to a Life project that involved four national parks (Rossetti et al., 2015; Bocci et al., 2016; Antonucci & Di Domenico, 2015).

Due to the relevant biodiversity value and to the presence of several habitats of naturalistic interest, 18 Special Areas of Conservation (SACs) and 5 Special Protection Areas (SPA) were established, according to the Habitats Directive 92/43/CEE, to the Directive 79/409/CEE and to the Birds Directive 2009/147. These areas, fully or partly included in the Park, build the framework of the Natura 2000 network in the southern portion of the Umbrian-Marchean Apennines and have an important part in the project "APE - Apennines Park of Europe".

The National Park of the Sibillini Mountains is a territory where biodiversity, history and culture has contributed in defining a unique and unrepeatable reality.

The localities considered in the present paper (Fig. 1), in particular, are the following: Rifugio Zilioli (Arquata del Tronto, Ascoli Piceno province), mountain hut surrounded by stony ground and meadows, 2,242 m asl; Pizzo del Diavolo eastern side (Montemonaco, Ascoli Piceno province), stony ground, 1,892–1,979 m asl.

MATERIAL AND METHODS

During a research committed by National Park of the Sibillini Authority to confirm the presence of the snow vole *Chionomys nivalis* (Martins, 1842) (Rodentia Cricetidae) in the protect area (Nappi et al., 2017), some trapping sessions were carried out in 11 stations of the Park, by using sherman, longworth, trip trap, home made cage traps and hair tubes. The captures and the tissue sampling were performed under authorization of the National Park Authority.

Since the morphological similarity with *A. flavicollis*, to identify the specimens we sequenced a fragment of the mitochondrial gene for the Cytochrome b (cytb) following the protocol in Nappi et al. (2017). Briefly, a tissue sample was collected from the ear flap with a biopsy punch and stored in 95% ethanol.

Genomic DNA was extracted by means of the universal extraction protocol of Aljanabi & Martinez (1997) with proteinase K and DNA precipitation with isopropanol. We used standard PCR protocols to amplify two mitochondrial fragments of cytochrome b (cytb). The primers used for the amplifications were L15408-ATA GAC AAA TCC CAT TCC A and H15915-TCT CCA TTT CTG GTT TAC AAG AC.

Amplifications were performed by polymerase chain reaction (PCR) in a Biometra Thermocycler machine. Sequencing was carried out by an external service (MACROGEN). The resulting sequence was 1071 bp (GenBank accession number to be provided upon acceptance). We used the blastn suite (Altschul et al., 1990) to identified the specimens.

RESULTS

The blastn suite, run with the obtained sequenced (442–445 bp), clearly indicated that the specimens belonged to *A. sylvaticus* having a 99% of identity with other *A. sylvaticus* sequences present in GenBank.

Two *A. sylvaticus* were captured around the Rifugio Zilioli (03.VII.2014) and two in Pizzo del Diavolo eastern side (03.VII.2014 and 06.VII.2014).

DISCUSSION

Although *A. sylvaticus* is an adaptable species, it does not seem to be reported, in Italy, in rocky environments. In Lombardia, *A. sylvaticus* was recorded in a great variety of habitats, except the rocky areas (Canova, 2001); in Umbria, it is present in deciduous, evergreen sclerophylls and riparian habitats, in grasslands, cultivated field and urban areas (Gaggi & Paci, 2014); in Roma province, it was found in very extensive woods, cultivated fields and urban areas (Capizzi, 2009).

As regards to the territory of the National Park of the Sibillini Mountains, from a research carried out in Val di Bove by the analysis of red fox *Vulpes vulpes* (Linnaeus, 1758) and mustelids scats, the presence of *Apodemus* sp. was detected in a border environment between coniferous forest and secondary grassland, between 1,500 and 1,700 m (Gaggi et al., 2013).

Considering the map of the potential vegetation of the Sibillini Mountains (Fig. 2), one can be deduced that in the past, the wooded areas, favorite environments of *A. sylvaticus*, were much more extensive. Although the majority of the environments present today, in the Park, is also suitable for *A. sylvaticus* (Fig. 3), the competition with rodents more related to woods, shrublands and grasslands, may have pushed some individuals to environments where the species, at least in Italy, is not reported.

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The occult spread of the invasive brown marmorated stink bug, *Halyomorpha halys* (Stål, 1855) (Hemiptera Pentatomidae), in Sardinia (Italy)

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ABSTRACT The invasive brown marmorated stink bug, *Halyomorpha halys* (Stål, 1855) (Hemiptera Pentatomidae), was recorded in autumn 2018 in Sassari (northern Sardinia, Italy), after a previous finding in Cagliari (over 200 km away in southern Sardinia) in autumn 2016. It is not clear whether the species has already spread throughout the Sardinia or whether the sighting in the North of Sardinia is due to a second introduction. However, it is usual for this species to have a long period with low population level after its first introduction into a new area. The presence of this very polyphagous alien species is a serious hazard for Sardinian agriculture.

KEY WORDS Alien insects; nuisance urban pest; agricultural pest; Italy; Europe.

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INTRODUCTION

The Hemiptera Pentatomidae *Halyomorpha halys* (Stål, 1855), known as the brown marmorated stink bug, is native to Asia, where it is considered a nuisance pest in urban areas due to its overwintering in buildings, and an agricultural pest on fruits and seeds (Lee et al., 2013). In the last two decades it is become invasive in North America and Europe, has been become established in Chile, near Santiago, and has been found in shipments from the United States and Asia to New Zealand and Australia. The timing of the invasions and current distribution in Europe have been summarized by Cianferoni et al. (2018).

Its autumnal shelter-seeking behaviour facilitates both the spread across wide geographical areas and the short-range secondary translocations through human activities, and repeated independent introductions are likely (Hamilton et al., 2018; Leskey & Nielsen, 2018). Current genetic data suggest a mixed origin of both the European (Cesari et al., 2015, 2017) and the West coast of the United States populations (Hamilton et al., 2018).

RESULTS

Between the 16th October and the 17th December 2018, four findings (five specimens) of *H. halys*

were recorded in the city of Sassari (northern Sardinia, Italy) and its surroundings. All the specimens were collected inside buildings, and each was collected (Fig. 1), identified and conserved in the collection of one of the authors (LL) (Table 1). This record is the second in Sardinia (but the first for the North of the island), the previous one regarded two specimens collected in the city of Cagliari in autumn 2016 (Dioli et al., 2016).

No other reports about the presence of this species in Sardinia are known to the authors (Fig. 2). A survey on crops in experimental stations of Agris Sardegna in the neighborhood of Cagliari, Oristano and Sassari during 2018 did not reveal the bug's presence. However, it is not clear whether the species has already spread throughout the Sardinia or it has been introduced more than once and in different locations.

Figure 1. *Halyomorpha halys* collected inside a building of Sassari city (Italy).

DISCUSSION

Typically, after the introduction into a new area, this species shows low population levels for a long period. In USA, the first specimens were collected in 1996, but the presence of the species became evident only five years later, and invasive after a decade (Hamilton et al., 2018). On mainland Italy, similarly, the first specimen was collected in 2007, but only in 2012 was the species extensively detected (Cianferoni et al., 2018).

In its first stages of invasion the species appears to be only an urban pest, because of its overwintering in houses and commercial buildings, whereas the agricultural problems come later. This has been confirmed many times in several countries in North America (Hoebeke & Carter, 2003; Gariepy et al., 2014) and Europe (for example: Milonas & Parsinevelos, 2014; Macavei et al., 2015; Rabitsch & Friebe, 2015, Simov, 2016). The slow and silent spread of this pest should not be underestimated. The brown marmorated stink bug could be a serious threat for Sardinian agriculture.

According to the model proposed by Kriticos et al. (2017), Sardinia, in particular its western coast, appears to be a suitable area for *H. halys*. Three areas - the southern Sulcis, the central Oristano Plain, and the northern Nurra - reach the same suitability level as a large part of northern and central Italy. All three of these areas have very important

#	Collection date	Locality	Coordinate N	Coordinate E	Specimens	Collector
1	16 Oct 2018	Sassari	40.72723	8.56915	2 males	V. Ligios
2	19 Oct 2018	Sassari	40.71679	8.57006	1 female	V. Ligios
3	14 Dec 2018	Li Punti	40.75490	8.49679	1 female	G. Medde
4	17 Dec 2018	Sassari	40.72414	8.56023	1 male	A. Muroni

Table 1. *Halyomorpha halys* records from North Sardinia (Italy).

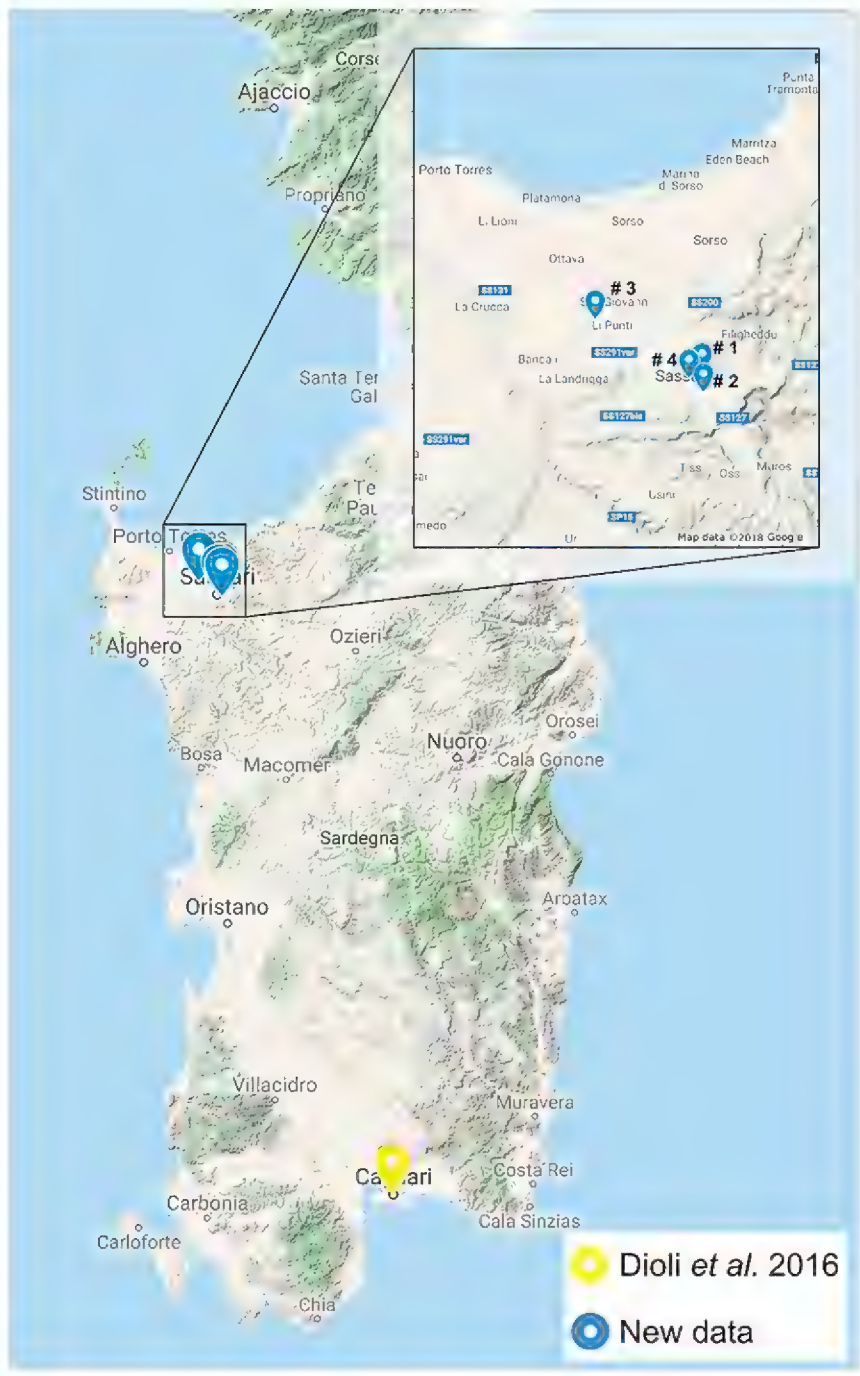

Figure 1. Sites in which *Halyomorpha halys* was collected in Sardinia (Italy). Numbers refer to the data cited in Table 1.

agricultural productions potentially threatened by the brown marmorated stink bug which is able to damage almost every fruit or seed of agricultural importance (Leskey & Nielsen, 2018) including rice (Lupi et al., 2017). Moreover, this bug is also able to become a key pest of additional crops in invaded countries (Lee et al., 2013).

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